FINAL REPORT

DOCUMENTATION AND ASSESSMENT OF FLOODING ALONG THE MIRAMICHI RIVER IN THE NEWCASTLE - CHATHAM AREA

Prepared for: THE FLOOD RISK MAPPING TECHNICAL COMMITTEE
CANADA - NEW BRUNSWICK FLOOD DAMAGE REDUCTION PROGRAM

Prepared by: WMS ASSOCIATES LTD.

WMS 3029
March 1990

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OBJECTIVES

The objective of this study is to investigate the nature, history and extent of flooding along the Miramichi River in the Newcastle-Chatham area. The study area has a history of flooding which is documented back to 1874 when flooding was noted in low-lying farm land. In 1875 water was reported over the road along Castle Street in Newcastle. The most significant flooding in the area occurred in 1970 when an ice jam formed near the Morrissy Bridge and caused extensive flooding in Newcastle.

Another objective of the study is to review the hydrotechnical aspects of the study area to evaluate some of the causative factors of the flooding. Flooding in the area is caused by high tides, heavy spring runoff, ice-jamming or a combination of these factors. Ice jamming affects the Town of Newcastle and areas upstream. The lower reaches of the study area are primarily affected by flooding from high water levels caused by storm surge and high tides.

STUDY AREA

The study area is comprised of the flood plain of the Miramichi River from Nelson Junction to Loggieville (Figure 1.1), including the Towns of Newcastle (Figure 1.2) and Chatham (Figure 1.3). The study area also includes the communities of Nelson-Miramichi, Chatham Head, Nordin, Douglastown and Lower Newcastle.

SCOPE OF WORK

An initial investigation was conducted using previous reports, photographs, newspapers and historical archives. This investigation provided the dates and brief descriptions of major flood events in the study area. The physical effects and extent of flooding were determined through field investigations, where possible.

Local residents and officials who have knowledge of past floods were interviewed to obtain details of the events. A questionnaire was developed to guide the interviewer, ensuring that interviews were conducted consistently. The objective of the interviews was to identify known flood limits from past events and to obtain available photographic or other evidence of these.

A ranking system developed for previous historic flood studies (WMS 1989; Snyder 1989) was used to evaluate the reliability of flood levels and reference points identified. The objective of the evaluation of the reference points was to ensure that the points identified for later surveying provide good spatial coverage of the study area with a sampling from as many known flood events as possible.

The water levels obtained were plotted on a profile of the study area to allow comparison of the elevations for specific flood events and to determine the maximum envelope of flooding. Since the study area is confined to the banks of the Miramichi River, a single profile of the River was used in plotting the points obtained in the field survey. The elevations were also plotted on topographic maps which were then used to determine the limits of flooding in the study area.

The open water flow for a 1 in 100 year return period event was estimated at the Morrissy Bridge in Newcastle using regional flood frequency methods (DMAE and IWD 1987). Information on antecedent weather and tidal conditions at the time of flooding events was collected and summarized to allow an evaluation of the causative factors of flooding in the area.

CONCLUSIONS AND RECOMMENDATIONS

This study determined that the floods of 1940, 1970 and 1988 produced the highest water levels on record in the study area. The maximum envelope of flooding was determined based on the highest water levels from these events. Elevations of the maximum envelope of flooding were determined along the length of the study area and can be used to establish the flood risk areas.

The flood of 1970 was a result of an ice jam located downstream of the Morrissy Bridge in Newcastle which caused extensive flooding of Newcastle and the area upstream.

The 1940 and 1988 events were the result of extremely high tides caused by storm surges. These events produced the maximum water levels for the portion of the study area downstream of Newcastle.

It was determined that some localized flooding occurs within Newcastle and Chatham due to the capacity of the storm water drainage system being exceeded. This flooding occurs during times of high runoff from the local drainage areas within these Towns. This study did not delineate the extent of inundation from this type of flooding, but it was determined that some flooding does occur outside the maximum envelope of flooding due to these localized effects.

The water levels found in this study were reported as elevations of flooding or heights against structures. The exact extent of inundation was not given at these points and was estimated from the topographic mapping of the area.

The 1 in 100 year flow on the Miramichi River at the Morrissy Bridge was estimated at 5600 m^3/s. It was determined that this flow would not cause a significant increase in the water level above the normal tidal range.

It is recommended that the maximum envelope of flooding determined in this study be used in the designation of flood risk areas within the study area.

It is also recommended that any developments within the study area which encroach upon the river or restrict river flow be carefully considered in relation to their effect on the ice regime and ice jams. New construction such as bridges and wharves should not restrict the movement of ice or present new lodgement points which could cause an ice run to stop and jam. Such changes could increase the severity of jamming and increase the maximum envelope of flooding within the study area.

Localized flooding within Newcastle and Chatham has occurred due to under capacity of storm water drainage systems. It is recommended that a review of the storm water drainage capacity be undertaken to highlight changes to the system which could be carried out to alleviate this type of flooding.

OBJECTIFS

Cette étude a pour but d'étudier la nature, l'histoire et l'étendue des inondations le long de la rivière Miramichi dans la région de Newcastle-Chatham. Il existe, pour la région étudiée, de la documentation sur les inondations qui remonte à 1874, époque où des inondations ont été signalées dans les zones agricoles basses. En 1875, la rue Castle à Newcastle avait été inondée. L'inondation la plus grave enregistrée dans la région est survenue en 1970 lorsqu'un embâcle près du pont Morrissy a grandement inondé Newcastle.

Un autre objectif de l'étude est d'analyser les aspects hydrotechniques de la région étudiée pour analyser certaines causes des inondations. Les inondations dans la région sont provoquées par les marées hautes, les écoulements du printemps, les embâcles ou une combinaison de ces facteurs. Les embâcles affectent la ville de Newcastle et les zones en amont. Les plus bas secteurs de la région étudiée sont surtout affectés par les inondations provoquées par les niveaux d'eau élevés causés par les ondes de tempête et les hautes marées.

RÉGION ÉTUDIÉE

La région étudiée comprend les plaines inondables de la rivière Miramichi à partir de Nelson Junction jusqu'à Loggieville (figure 1.1), y compris les villes de Newcastle (figure 1.2) et Chatham (figure 1.3). Elle englobe également les localités de Nelson-Miramichi, Chatham Head, Nordin, Douglastown, et Lower Newcastle.

ÉTENDUE DES TRAVAUX

Une étude préliminaire a été effectuée à partir des rapports précédents, des photographies, des journaux et des archives historiques. Cette étude a permis d'identifier les dates et de fournir une courte description des inondations majeures survenues dans la région étudiée. Les effets physiques et l'étendue des inondations ont été déterminés par des études sur place, lorsque cela était possible.

On a interviewé des résidents et des représentants locaux qui possédaient des renseignements sur les inondations survenues, afin d'obtenir des détails sur ces événements. Un questionnaire a été préparé pour orienter l'intervieweur, afin que les entrevues soient effectuées de façon constante. L'objectif des entrevues était d'identifier les repères de crue connus à partir des événements précédents et d'obtenir les preuves photographiques ou autres disponibles.

Un système de classement établi pour les études des inondations précédentes (WMS 1989; Snyder 1989) a été utilisé afin d'évaluer la fiabilité des repères de crue et des niveaux de crue identifiés. On voulait, pour les études ultérieures, avoir accès à un vaste échantillonnage qui comprendrait le plus grand nombre de points identifiés possible et qui couvrirait la plus grande partie possible de la région étudiée.

Les niveaux d'eau obtenus ont été tracés sur un profil de la région étudiée afin de permettre la comparaison des élévations pour les inondations particulières, et afin de déterminer l'enveloppe maximale des niveaux de crue. Puisque la région étudiée est délimitée par les rives de la rivière de Miramichi, un seul profil de la rivière a été utilisé pour tracer les points obtenus lors de l'étude sur place. Les élévations ont été aussi tracées sur des cartes topographiques utilisées ensuite afin de déterminer les repères de crue dans la région étudiée.

Le débit de l'eau libre au pont Morrissy à Newcastle pour une période de récurrence d'une fois en 100 ans a été estimé à l'aide de méthodes régionales de fréquence de crue (MAME et IWD 1987). On a recueilli des données sur les conditions météorologiques et les marées antécédentes lors des inondations; ces données ont été résumées pour permettre une analyse des causes des inondations dans la région.

CONCLUSIONS ET RECOMMANDATIONS

L'étude a déterminé que les inondations de 1940, 1970 et 1988 ont produit les niveaux d'eau les plus élevés enregistrés dans la région étudiée. L'enveloppe maximale des

niveaux de crue a été déterminée en fonction des niveaux d'eau les plus élevés provoqués par ces événements. On a établi les élévations de l'enveloppe maximale des niveaux de crue le long de la région étudiée; ces données peuvent être utilisées pour identifier les zones inondables.

L'inondation de 1970 a été provoquée par un embâcle situé en aval du pont Morrissy à Newcastle qui a inondé une bonne partie de Newcastle et la zone en amont.

Les inondations de 1940 et 1988 ont été provoquées par des marées extrêmement hautes causées par les ondes de tempête. Ces événements ont produit les niveaux d'eau maximum pour la partie de la région étudiée située en amont de Newcastle.

On a déterminé que certaines inondations localisées à Newcastle et à Chatham sont dues au dépassement de la capacité du système de drainage pluvial. Ces inondations surviennent durant les périodes d'écoulement élevé provenant des bassins hydrographiques locaux à l'intérieur de ces villes. La présente étude n'a pas délimité l'étendue des inondations du genre, mais elle a permis d'établir que certaines inondations surviennent en dehors de l'enveloppe maximale des niveaux de crue, en raison de ces effets localisés.

Les niveaux d'eau enregistrés dans la présente étude ont été présentés comme des élévations de crue ou des hauteurs contre des charpentes. L'étendue exacte des inondations pour ces points n'a pas été fournie; elle a été estimée à partir de la cartographie topographique de la région.

Le débit pour une période de récurrence d'une fois en 100 ans sur la rivière Miramichi au pont Morrissy a été estimé à 5 600 m^3/s. On a déterminé que cet écoulement ne ferait pas augmenter grandement le niveau d'eau au-dessus du marnage normal.

On recommande que l'enveloppe maximale des niveaux de crue déterminée dans la présente étude serve à la désignation des zones inondables dans la région étudiée.

Il est aussi recommandé que tout aménagement à l'intérieur de la région étudiée qui empiète sur la rivière ou qui limite son débit soit étudié attentivement par rapport à ses effets sur le régime des glaces et les embâcles. Les nouvelles constructions telles que les ponts et les quais ne devraient pas limiter le mouvement des glaces, ni présenter de nouveaux points d'accumulation où les glaces en mouvement pourraient s'accumuler et provoquer des embâcles. Ces changements pourraient accroître la gravité des embâcles et augmenter l'enveloppe maximale des niveaux de crue dans la région étudiée.

Certaines inondations localisées à l'intérieur de Newcastle et Chatham se sont produites en raison de la sous-capacité du système de drainage pluvial. On recommande qu'une étude de la capacité de drainage des eaux pluviales soit entreprise pour signaler les changements qui pourraient être apportés au système afin d'atténuer ce type d'inondation.

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1.0 INTRODUCTION

1.1 Objectives

The objective of this study is to investigate the nature, history and extent of flooding along the Miramichi River in the Newcastle-Chatham area. The study area has a history of flooding which is documented back to 1874 when flooding was noted in low-lying farm land. In 1875 water was reported over the road along Castle Street in Newcastle. The most significant flooding in the area occurred in 1970 when an ice jam formed near the Morrissy Bridge and caused extensive flooding in Newcastle.

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1.3 Scope of Work

An initial investigation was conducted using previous reports, photographs, newspapers and historical archives. This investigation provided the dates and brief descriptions of major flood events in the study area. The physical effects and extent of flooding were determined through field investigations, where possible.

LIMIT OF STUDY AREA

NEWCASTLE

NORDIN

DOUGLASTOWN

MORRISSY BRIDGE

BUSHVILLE

CHATHAM HEAD

MIRAMICHI RIVER

Beaubears Island

DERBY JUNCTION

NELSON-MIRAMICHI

NELSON JUNCTION

MILLBANK

Middle Island

MIRAMICHI RIVER

LIMIT OF STUDY AREA

LOWER NEWCASTLE

LOGGIEVILLE

CHATHAM

LEGEND

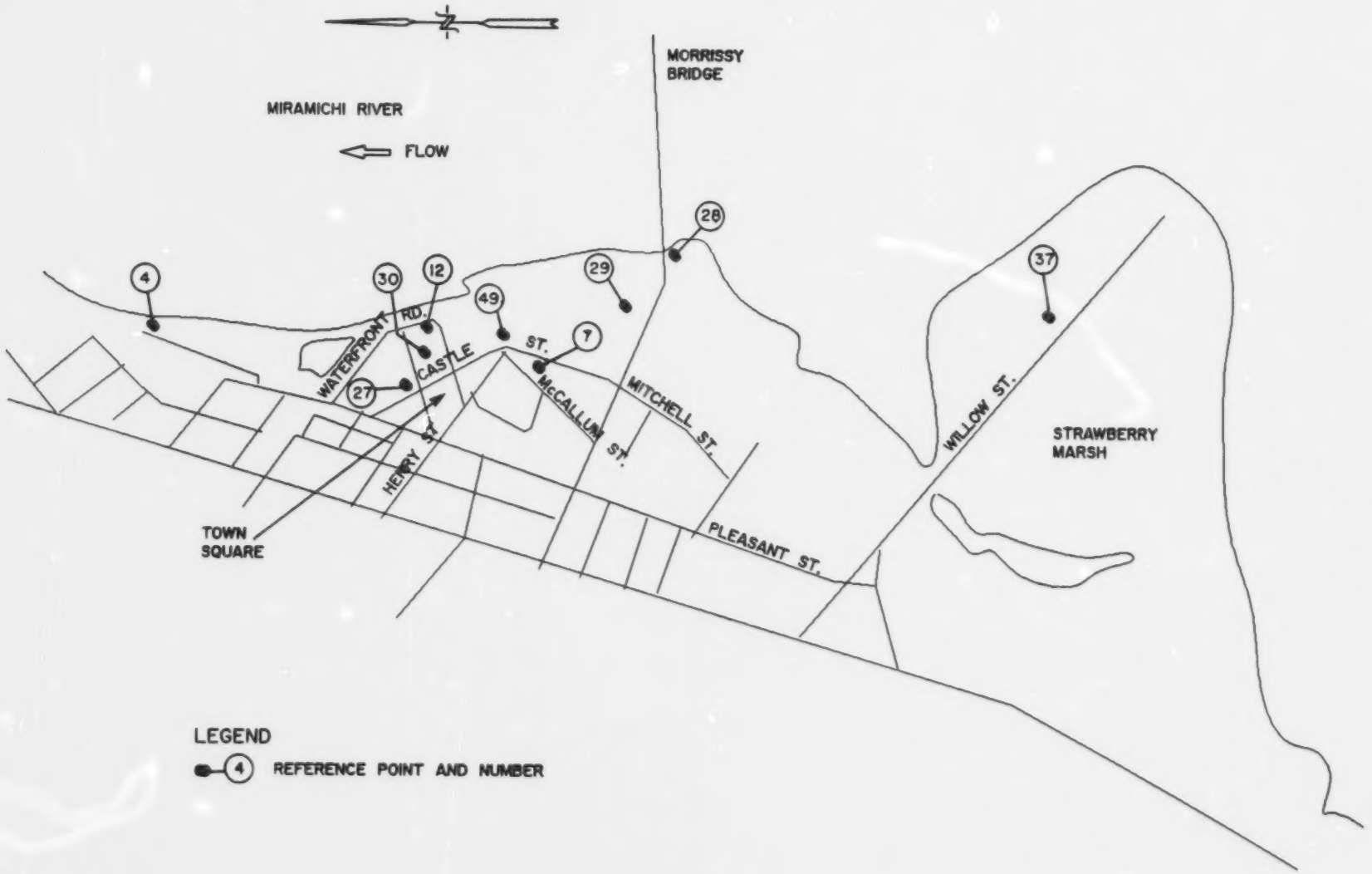
RAILWAYS
ROADS
LIMIT OF STUDY AREA

STUDY AREA

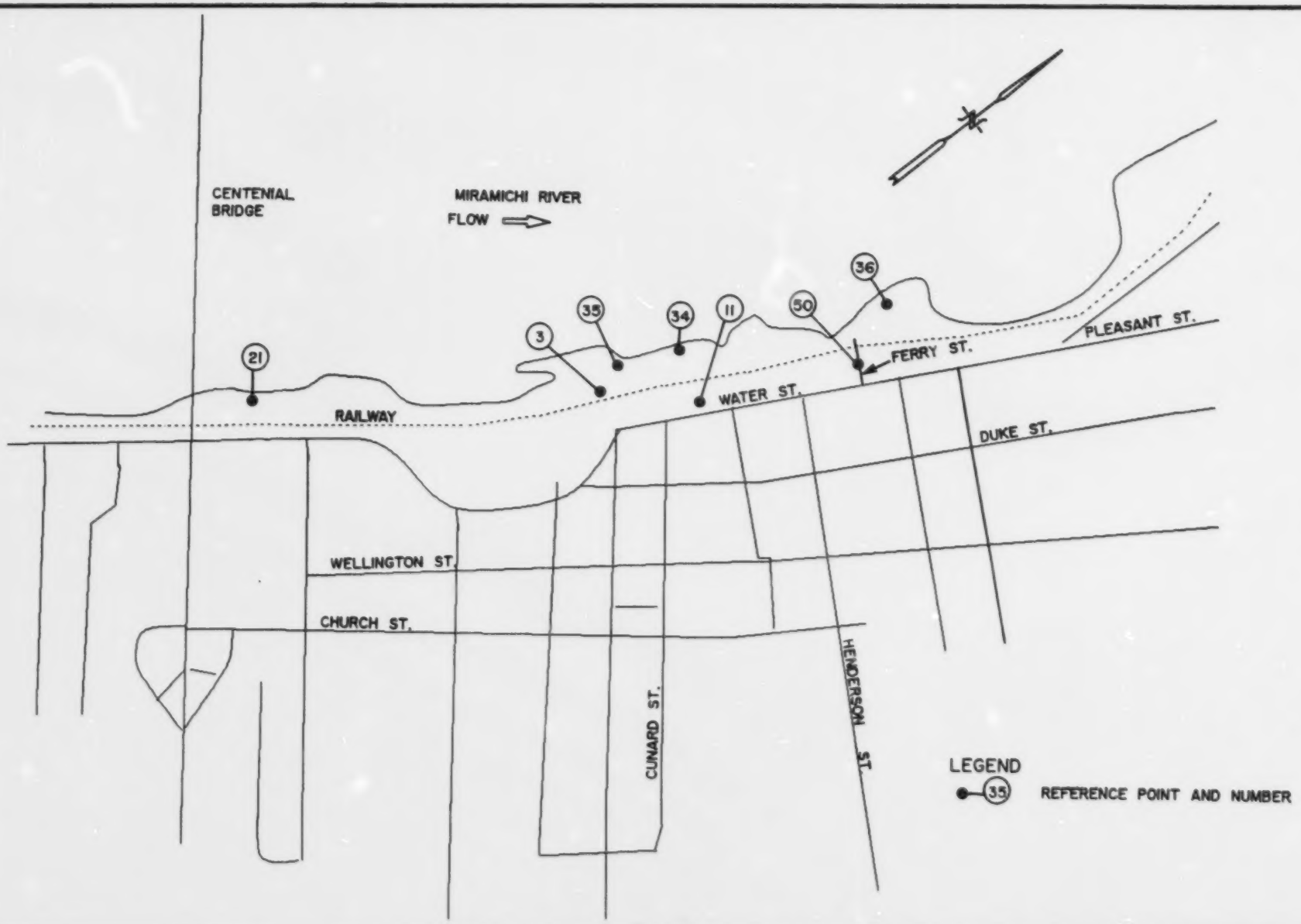
wms associates ltd.

ENVIRONMENTAL CONSULTANTS AND PLANNERS

SCALE: 1:50 000	DRAWN BY:
DRAWING No.: WMS 3029 FIG: 1.1	DATE: 90 03 22



TOWN OF NEWCASTLE	**wms** associates ltd. ENVIRONMENTAL CONSULTANTS AND PLANNERS	DATE: 90 03 23	SCALE: NTS
		PROJECT No.: 3029	FIGURE No.: 1.2



TOWN OF CHATHAM	**wms** associates ltd. ENVIRONMENTAL CONSULTANTS AND PLANNERS	DATE: 90 03 23	SCALE: NTS
		PROJECT No.: 3029	FIGURE No.: 1.3

Local residents and officials who have knowledge of past floods were interviewed to obtain details of the events. A questionnaire was developed to guide the interviewer, ensuring that interviews were conducted consistently. The objective of the interviews was to identify known flood limits from past events and to obtain available photographic or other evidence of these.

A ranking system developed for previous historic flood studies (WMS 1989; Snyder 1989) was used to evaluate the reliability of flood levels and reference points identified. The objective of the evaluation of the reference points was to ensure that the points identified for later surveying provide good spatial coverage of the study area with a sampling from as many known flood events as possible.

The water levels obtained were plotted on a profile of the study area to allow comparison of the elevations for specific flood events and to determine the maximum envelope of flooding. Since the study area is confined to the banks of the Miramichi River, a single profile of the River was used in plotting the points obtained in the field survey. The elevations were also plotted on topographic maps which were then used to determine the limits of flooding in the study area.

The open water flow for a 1 in 100 year return period event was estimated at the Morrissy Bridge in Newcastle using regional flood frequency methods (DMAE and IWD 1987). Information on antecedent weather and tidal conditions at the time of flooding events was collected and summarized to allow an evaluation of the causative factors of flooding in the area.

1.4 Authorization

WMS Associates Ltd. has undertaken this study for the New Brunswick Department of the Environment, under the Canada - New Brunswick Flood Damage Reduction Program. The study has been completed in consultation with a Technical Committee comprised of representatives from the Inland Waters Directorate of Environment Canada and from the Water Resource Planning Branch of the New Brunswick Department of the Environment.

2.0 FLOOD DOCUMENTATION

This chapter presents both the methodology used in the collection and compilation of flood documentation data and the methodology used to compile and evaluate the information so that water level reference points could be located in the field. The major flood events in the Newcastle-Chatham area are presented in Section 2.1.

The flood documentation portion of the study included the collection and thorough review of all existing information on past floods in the Newcastle-Chatham area. This included archival sources (Section 2.2) and interviews with members of the public using questionnaires (Section 2.3). Photographs of flooded areas were collected from these sources and supplemented by current photographs.

Mapping for the study area was collected and assembled. The entire study area was covered by three 1:50,000 scale National Topographic series maps (21 I/13, 21 P/03, and 21 P/04). Photocopies of the relevant portion containing the study area were used for reference in the field, and for recording reference point locations for the Field Guide (WMS 1990), which is issued as a supplement to this report. A total of eight LRIS 1:10,000 scale orthophoto maps were also used to locate and record reference points.

2.1 Past Flooding

A total of 42 flood events have been recorded commencing in 1874. There were four other floods reported in the late 1800s, with the most significant being that caused by rain in combination with a storm-driven high tide on November 3-4, 1897. Water flooded two shops and the intersection of Castle and McCallum Streets (Figure 1.2) in Newcastle and was reported to be level with the waterfront wharves.

A significant flood event also occurred in 1911 and several flood events since then were described as being the highest since 1911, establishing that event as the reference point for many years. Many of these 42 events occurred in the fall, and were the result of high tides driven by winds and storms. Table 2.1 presents a list of the known flood events which affected the study area.

TABLE 2.1: DATES OF FLOODING IN THE STUDY AREA

Flood Date	Flood Type	Flood Date	Flood Type
1988 Nov 21	tidal & rain		
1979 Jul 29	rain	1928 Apr 13	ice jam
1979 Jan 8-9	rain & melting snow	1927 Aug 24-25	rain
1978 Jan 25-28	ice jams	1925 Oct 30	rain & wind
1976 Feb 2-3	wind & rain	1925 Oct 16	storm driven tide
1974 Dec 9-10	high tides & wind	1923 Apr 29-May 9	freshet & ice jams
1974 Nov 27-28	rain & high tides	1923 Apr 9-12	melting snow
1970 Feb 2-6	ice jam & rain	1921 Apr ?	ice jam
1968 Oct 20-22	rain	1920 Mar 26	rain
1967 May 26-27	wind, rain, & tide	1918 Jul 19	rain
1960 May 17-18	rain	1915 Jul 8-9	wind & rain storm
1959 Jun 26	rain	1915 Apr 16-19	ice jam & rain
1953 Mar 26-Apr 3	ice jam & rain	1913 Apr 4	freshet
1950 Apr 20-24	rain & ice breakup	1912 Aug 16	rain
1950 Apr 8-9	tidal	1911 Jul 22	rain
1940 Sep 17-20	tidal & rain	1909 Oct 8	freshet
1939 Feb 24	rain	1902 Mar 17-23	rain
1938 Dec 2	storm driven tide	1897 Nov 3-4	storm driven high tide
1937 Nov 20	tidal	1884 Sep ?	tidal
1936 Mar 16-25	ice jam	1875 Apr 21	rain
1934 Apr 16-24	rain	1874 Jun 24	rain
1931 Jan 9	ice jam		

A flood which resulted in extensive damages occurred in the first week of February 1970, as a result of a combination of unseasonably warm temperatures, heavy rainfall and an early ice run-out on the Miramichi River (Section 3.2.3). Ice jams near the Morrissy Bridge caused flooding in Newcastle.

Flooding also occurred in late November of 1988 as a result of high spring tides and a "storm surge" caused by a storm with high easterly winds. This resulted in maximum water levels (Section 3.2.4) which greatly exceeded the predicted tidal elevations. This event, which affected the entire length of the study area causing inundation of wharves and river front property, has been described as the worst since the 1970 flood.

2.2 Data Sources

Information on flooding in the Newcastle-Chatham area was collected from a number of sources and reviewed. Two major sources of information were a report on historic floods in New Brunswick (Kindervater 1985) and a historical flood review of the Town of Newcastle (Nicholson 1982). These sources served as a starting point in the search for additional information.

Historical streamflow summaries provided daily and monthly data for hydrometric station 01BO001 on the Southwest Miramichi River at Blackville.

Temperature and precipitation data were obtained for the Chatham Airport meteorological station (Atmospheric Environment Service 1988). The Canadian Hydrographic Service (CHS) was contacted to obtain predicted and recorded tide levels for the Reference Port at Escuminac. Data was obtained corresponding to the 1988 flood event, but data corresponding to other flood events was not available (CHS 1988; D. Spear, pers. comm.).

In the course of the collection of background data, Provincial and Federal government sources were consulted, including both library and departmental files. Interviews of

knowledgeable individuals provided focus to the collection of these data. Government sources included the following:

- New Brunswick Department of the Environment, Fredericton;
- New Brunswick Department of Transportation, Fredericton; and
- New Brunswick Emergency Measures Organization, Fredericton.

The N.B. Department of the Environment provided files of newspaper and magazine clippings and reports. The Emergency Measures Organization provided access to reports, and files of photos and clippings. These sources provided additional background information on flood events but generally did not provide details which could lead to the determination of water levels in the field.

Libraries and archives were also consulted, as follows:

- Harriet Irving Library, University of New Brunswick, Fredericton;
- Provincial Archives, Fredericton; and
- Old Manse Library, Newcastle.

Microfilms of several Newcastle and Chatham newspapers plus the **Moncton Daily Times**, the **Evening Times-Globe**, the **Daily Gleaner** and the **Telegraph-Journal** were consulted at the Harriet Irving Library. The Provincial Archives provided access to files of historical photographs.

The Newcastle and Chatham area has had weekly (originally tri-and bi-weekly) newspapers since at least 1829, under various names. The following issues of local papers were examined:

- **Chatham Commercial**, 1898-1929;
- **The Commercial & The World**, 1930-1963;
- **Chatham Gazette**, 1915-1989;
- **Chatham Gleaner**, 1829-1880;
- **Leader**, 1893;
- **Miramichi Leader**, 1979 - ;
- **Miramichi Press**, 1977-1978;
- **Miramichi Weekend**, 1979-1987;
- **Nelson Union Advocate**, 1909-1911;
- **North Shore Leader**, 1906-1969;
- **Northumberland News**, 1981-1983; and
- **Union Advocate**, 1868-1889.

All issues of the **North Shore Leader**, the **Union Advocate**, the **Nelson Union Advocate**, and **Miramichi Leader** were reviewed. Specific flood dates were examined for the other local newspapers. Local floods were either covered extensively in the local weekly newspaper or were given cursory coverage if the event happened several days before the date of issue. The **Telegraph-Journal**, the **Evening Times-Globe**, the

Daily Gleaner and the **Moncton Daily Times** were consulted for the dates before, during and after each flood event, in order to provide maximum coverage of the event. The larger flood events received extensive coverage from all newspapers, but the minor floods received only brief mention.

2.3 Interviews and Questionnaires

Historical data, reports and newspaper accounts are valuable for rounding out the background information for flood events, but the majority of actual flood level reference points, i.e., points which can actually be measured in the field, are usually obtained from personal interviews of local residents. This became apparent during a similar interview phase conducted for a previous study of flooding along the Magaguadavic River at St. George (WMS 1989).

In order to guide the interviewer and to ensure that all interviewees were asked a consistent set of questions, the interviewer followed a Local Residents and Officials Interview Guide, which was based on those developed for the Magaguadavic River Study (WMS 1989). A Flood Event Information Form was also filled out for each flood event described during the interview. Samples of these forms are provided in Appendix A.

A total of 50 interviews were conducted with Newcastle-Chatham area residents between September 20 and October 4, 1989. A list of the persons interviewed is included in Appendix B. Initial interviews were held with the former Deputy-Mayor of Newcastle and other officials of the Towns of Newcastle and Chatham. These interviews provided initial leads for the interviewer, as well as preliminary descriptions of some flood events; subsequent interviews uncovered more leads.

The Interview Guide was also used to record leads to other residents or officials who might have information on flood events and reference points. The residents were asked general questions on flooding, and also specific question, including dates and locations of flood events. The Flood Event Information Form was completed to obtain information specific to the flood, including:

- dates of flood event, including peak and first and last dates (if known);
- type of flood (ice run, ice jam, open water or tidal);
- location of ice runs or ice jams;
- extent, location and height of flood waters;
- direct or indirect damages (type of damage and cost);
- location of any physical evidence of flooding (eg., high water marks, ice scars or reference points); and
- availability of photographs of the event.

The use of separate questionnaires for each flood event facilitated cross-referencing of interviews for the same flood events. The forms were also useful in

- maintaining the consistency of the interview method; and
- ensuring that flood details, photographs of the event, and leads to additional residents were obtained.

3.0 DATA COMPILATION

The evaluation of the flood data collected during the flood documentation portion of this study is discussed in Section 3.1. Detailed flood descriptions of four major floods in the Newcastle-Chatham area are presented in Section 3.2. This section also includes a brief description of annual flooding.

The field survey was conducted after the floods were documented and reference points were determined. The field survey located the reference points in the field and measured their elevations (Section 3.3).

3.1 Data Evaluation

The data collected during the interview survey with local residents and officials were assembled and reviewed, and were supplemented by information from the archival sources where possible. The data were used to produce a list of points for which sufficient detail was obtained to provide a point in the field at which the level of flooding could be determined. A total of 50 of these "reference points" were obtained. At some of the points, information was obtained on more than one flooding event, so that a total of 57 potential water levels were found.

Not all of the water levels could be determined with the same level of accuracy. Therefore, it was necessary to use a method of ranking the points to allow a comparison to be made of their reliability. The ranking method used was developed for a similar historic flood study for the Magaguadavic River (WMS 1989; Snyder 1989). The following describes the categories used in the ranking system and the assumed range of elevation, which is recognized as being a subjective interpretation of the ranked categories:

- **"Good"** points are the most reliable and are points for which there is a photograph or physical evidence of the maximum flood level;

- **"Reasonable"** points are those for which there is a photograph, but the

building has been changed since the photograph was taken; reasonable points are also those for which a measurement was made by the resident or by others at the time of flooding but the exact reference was not recorded as a physical mark or by photography;

- **"Approximate"** points are levels related to existing structures against which the resident was able to demonstrate an approximate water level; such points are usually those about which the person describing the level had first-hand knowledge;

- **"Vague"** points are flood levels relating to second hand knowledge estimates, or levels in relation to structures no longer in existence; and

- **"No Elevation"** is used to designate flood events at a reference point for which commentary is available, but not in sufficient detail to allow a water level to be determined; this category is also used to designate areas or points which are reported not to be inundated during flood events but are located near the flood plain.

A preliminary evaluation was made of these water level reference points. This evaluation was used as a screening process to assign the ranking to the points and to determine which points should be surveyed in the field to provide an optimal coverage of the extent of flooding in the study area. The screening process was used to select reliable points which would provide a good spatial coverage of the study area using the most reliable data. In addition, the points were selected to provide a sampling from as many flood events as possible. Table 3.1 presents the results of the preliminary ranking of the reference points.

The preliminary evaluation also considered the type and source of information which was used to obtain the water level at each reference point. The sources of information were classified as follows:

TABLE 3.1: PRELIMINARY RANKING OF POINTS

Point	1940	1953	1970	1976	1988	Annual	Unknown	Point
1					A			1
2					R			2
3				R				3
4	R		A		A			4
5			A					5
6			G		R			6
7	Y		A					7
8			G					8
9						V		9
10							A	10
11							A	11
12	A							12
13							V	13
14						V		14
15					R			15
16							V	16
17			R					17
18			R					18
19			A					19
20		A	A					20
21					A			21
22			R					22
23							V	23
24						V		24
25			A		A			25
26						V		26
27			A					27
28			R					28
29			A					29
30			A					30
31						V		31
32					A			32
33					R			33
34					A			34
35					A			35
36					V			36
37			V			V		37
38							R	38
39					A			39
40					V			40
41							Y	41
42							Y	42
43							Y	43
44							Y	44
45							Y	45
46							Y	46
47							Y	47
48							Y	48
49	V							49
50	V							50
Potential Points	5	1	16	1	14	6	14	57

Label	Description	Range
G	Good	± 25 mm
R	Reasonable	± 75 mm
A	Approximate	± 150 mm
V	Vague	± 300 mm
Y	No elevation	

- anecdotal (verbal description of the event or level);
- newspaper or archival account; or
- photographs taken during the flood event.

All data from the archival research and interview process was collated into a draft "Field Guide" (WMS 1990) which provided the information required to assess the points; it is issued as a supplement to this report. The Field Guide contains the following information:

- reference point number;
- sketch map showing point location;
- description of reference point location and water level(s) at the point;
- photograph(s) of the water level during the flood event (if available); and
- current photograph(s) of the reference point as it now appears showing where the water level is and how the structure or site appears from the nearest road.

The Field Guide was used by the survey crew to locate the points in the field during a field reconnaissance following the preliminary assessment. The ranking of each point together with additional information indicated the location of the water level measurement. The practicality of surveying the indicated reference points was also assessed.

The mandate of the study was to survey a total of 40 reference points in the field. The preliminary screening process and reconnaissance visit were used to determine which of the 50 points found during the research portion of the study should receive priority for

surveying in the field. The approximate locations of the reference points are shown in Figure 3.1.

3.2 Flood Descriptions

There have been four major flood events along the Miramichi River in the Newcastle-Chatham area within recent memory, including the following years:

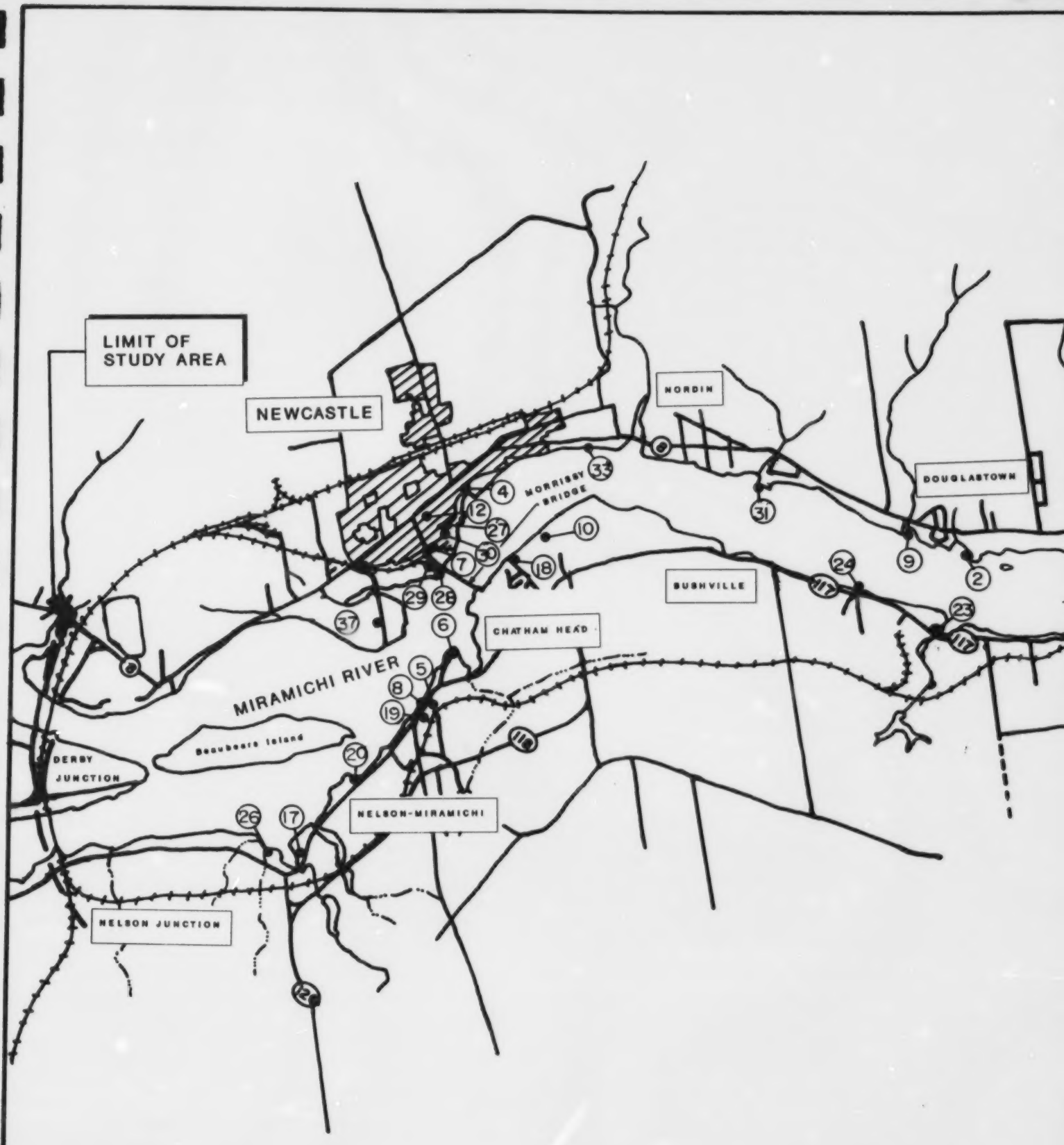
- 1940;
- 1953;
- 1970; and
- 1988.

These are described in the following Sections.

3.2.1 Flooding of 1940

On September 17, 1940 a storm-driven tide coinciding with the full moon caused extensive flooding in the study area and caused damage estimated in the hundreds of thousands of dollars (The Chatham Gazette, Sept. 18, 1940) At the height of the gale, the easterly winds measured 95 to 130 km/hr and the storm was accompanied by 80 mm of rain.

Several downtown Newcastle merchants suffered losses, including The North Shore Leader located on Mitchell Street, which had one and a half tons of newsprint spoiled (North Shore Leader, Sept. 20, 1940). There was a great deal of damage done to residential households, especially in the Mitchell Street area, where a number of cars were submerged in garages. The water level between The North Shore Leader office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CHATHAM HEAD
MIRAMICHI RIVER
Beaubears Island
DERBY JUNCTION
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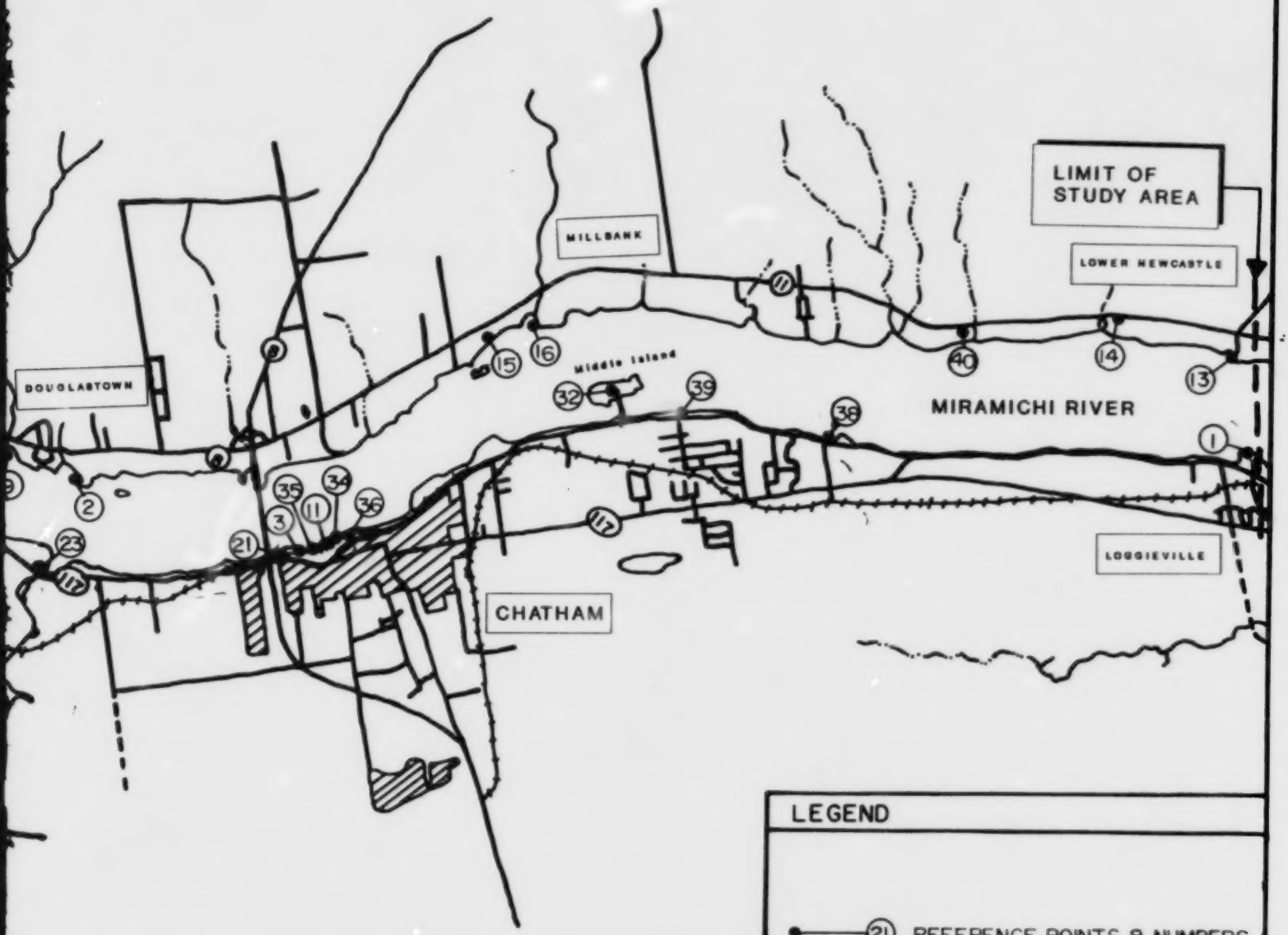

LEGEND

(21) REFERENCE POINTS & NUMBERS
RAILWAYS
ROADS
LIMIT OF STUDY AREA

REFERENCE POINTS

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and the Eastern Hay and Feed Company was 1.2 m above the roadway on Mitchell Street (Figure 1.2). Flood debris entered the Town Square and there was major flooding at the Castle and Henry Streets junction.

Many wood products were lost as stock was washed off wharves along the waterfront in Newcastle; British Canadian Pitwood Ltd. lost an estimated $27,000 off their wharf (North Shore Leader, Sept. 20, 1940). Heavy losses were also sustained by the Robin Hood Flour Company, whose warehouse, located on one of the Newcastle wharves, flooded to a depth of 1 m. Atlantic Wholesalers on Mitchell Street (now Thorne's) had all the labels washed off food cans stored in the basement.

The shore road between Loggieville and Chatham (Figure 1.1) was covered with debris from fallen trees and poles. Lumber products from various wood companies were deposited along the road by the high tides. Ferry slips were jammed with logs and damaged by wave action (The Moncton Daily Times, Sept. 19, 1940)

There was extensive wind damage in Chatham and the waterfront area suffered a great deal of damage from flooding (The Chatham Gazette, Sept. 18, 1940). The tide rose 600 mm above the railway tracks at the Ferry Street crossing and the line was washed out in many places (Figure 1.3). Flood water flowed over the wharves almost up to Water Street, flooding cellars of buildings on the north side of Water Street. The pressroom in the basement of The Commercial and The World building was inundated to a depth of 1.4 m, covering the newspaper press and destroying thousands of sheets of newsprint.

In the course of the study, a total of 5 points were found relating to the 1940 flood. Three of the points were obtained from newspaper references. The descriptions of the points were vague due to changes to structures in the area since 1940, but sufficient information was obtained to determine that the 1940 flood was the maximum historic flood in the section of the study area downstream of Newcastle.

3.2.2 Flooding of 1953

At the end of March 1953, flooding occurred in the study area which was caused by rapid snowmelt and resultant heavy runoff. During the previous fall and early winter there was very little snow; the frost penetrated the ground to greater depth than normal. There were heavy snowfalls in the last few weeks of winter. This melted quickly due to a period of very mild weather accompanied by heavy rainfall which lasted for 36 hours. Water flowed over the frozen ground directly into the stream network. In the tributaries where river ice held, the water ran over the top of the ice. Where ice breakup had commenced, the increased river flow caused a heavy ice run and many ice jams. The majority of ice jam damage was limited to the Southwest and Northwest Miramichi Rivers, where camps were flooded and people were evacuated. Log booms on both rivers were washed out, many of these were deposited in Newcastle.

In Newcastle the majority of the flooding was caused by runoff exceeding the capacity of the storm water drainage systems. Some residential houses in the Town had flooded basements, with depths of water up to 2 m. Furnaces were extinguished or rendered inoperative. The surface water drained off fairly quickly after the rainfall event (North Shore Leader, April 3, 1953).

Flooding in Chatham was the result of streams and roadside ditches being unable to handle the large volume of surface water (The Commercial and The World, March 26, 1953). Flooding was serious in various parts of the Town, with the press room in the basement of The Commercial and The World building flooded to a depth of 200 mm. The area of Church and Wellington Streets, between Henderson and Cunard Streets, also experienced flooding. Wellington Street buildings had their basements flooded by up to 2 m of water, with lesser amounts in basements in other parts of Town. As in Newcastle, many Chatham residents and businesses were without heat due to flooding of furnaces located in basements of buildings.

The rail line at Derby Junction (Figure 1.1) was reported to be under 1.2 m of water and in danger of being washed out (Moncton Daily Times, April 3, 1953).

Only one water level reference point was found for the March 26 to April 3, 1953 flood. The flood event was not the worst on record and people interviewed did not recall specific details about the flood or water levels reached in the study area.

3.2.3 Flooding of 1970

The major recent flood event in the study area was the ice jam flood of February 2 to 6, 1970. This event affected the Newcastle area only and caused water levels which exceeded those reached by the flood of 1940. Mild temperatures and heavy rain caused a mid-winter thaw with heavy runoff and high river flow. This caused breakup of the ice on the Northwest and Southwest Miramichi Rivers, which began to run on February 4, jamming frequently as it moved downstream. The following was observed by the WMS field crew written above the line demarcating the high water mark on the inside door of Stephen McCarthy's barn, Nelson- Miramichi:

The ice ran out of the Southwest Miramichi on February 4, 1970.

The ice jammed and washed out bridges in the upper reaches of the Northwest and Southwest Miramichi Rivers and tributaries (upstream of the study area) at Renous, Blackville and Pineville. Water flowed over bridges at Red Bank, Johnston, Somers, Waverton and Quarryville, and ice jammed against the railway bridge at Upper Nelson causing flooding in Nelson-Miramichi (North Shore Leader, Feb. 12, 1970). A major ice jam occurred in Newcastle just below the Morrissy Bridge (Figure 1.2), the ice jam was reported to be 12 to 15 m thick and was high enough to nearly touch the bottom of the Morrissy Bridge deck (The Telegraph-Journal, February 6, 1970).

The major flooding occurred from February 3-5, 1970. Newcastle wharves and the business district were inundated and the water supply contaminated when overland river water entered the Newcastle wells (North Shore Leader, February 12, 1970). There was extensive damage upstream of Newcastle including the pulp and paper mills on both sides of the River. Most houses on Main Street in Nelson-Miramichi were inundated. The Town dump at Strawberry Marsh and most of the waterfront businesses and stores around the Town Square in Newcastle were flooded to some

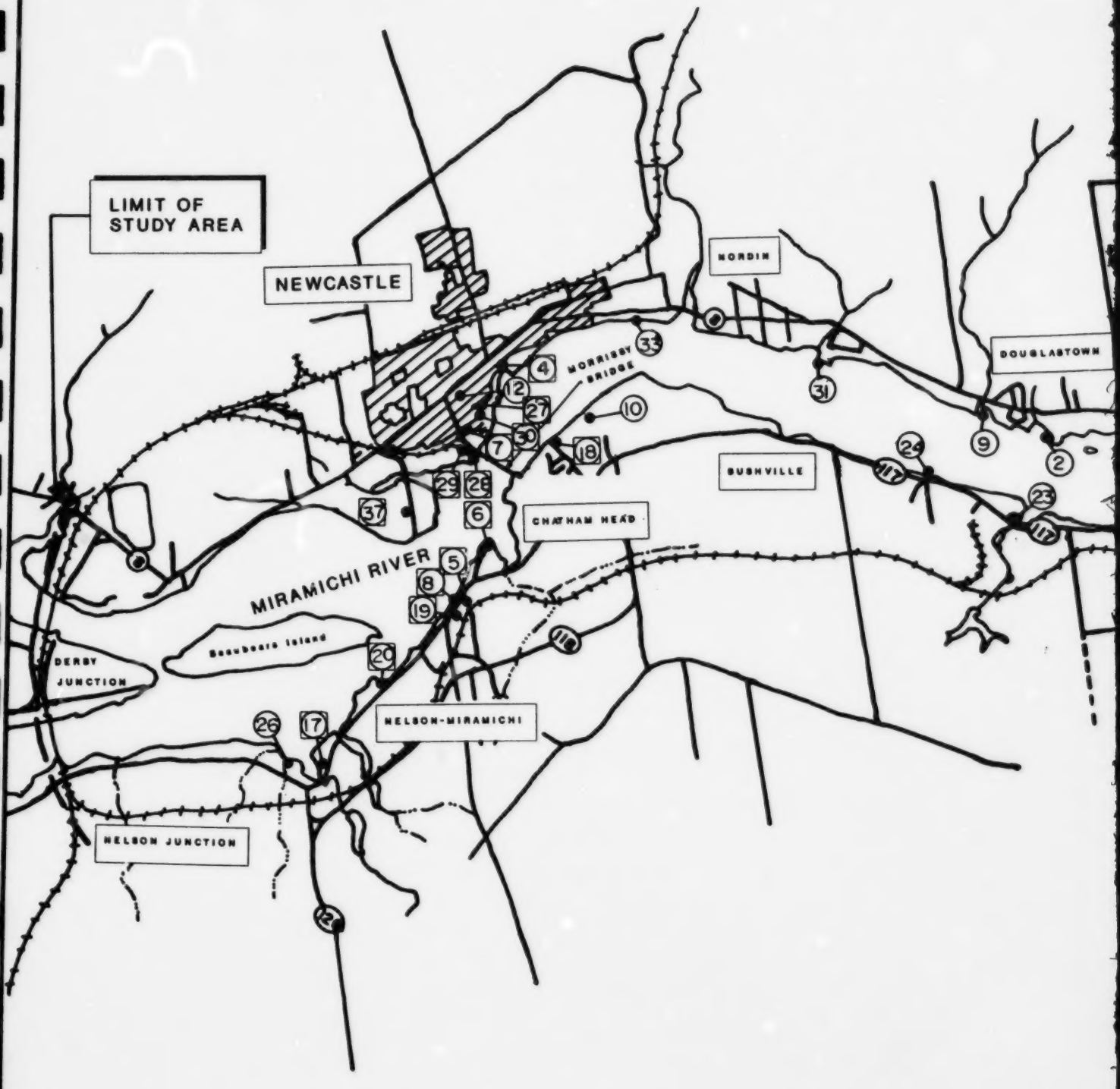
extent. Fifty cars at a Newcastle automobile dealership located on Route 126 near McCallum Street were covered by flood waters (Figure 1.2). Damage to highways and bridges in the entire Northumberland County was estimated at approximately $2,000,000 (including repairs and upgrading). Damage to electric power distribution systems in the Chatham District cost $34,324 to repair (Kindervater 1985).

The largest number of water level reference points found during the study were for flooding related to the 1970 event. A total of 17 points were found in the area between Newcastle to Upper Nelson (Figure 3.2). Most of these points were located from interviews but some were located from photographs taken during the flood event by local residents. Changes to the Newcastle waterfront area due to the construction of a new marine terminal made identification of water level points from photographs difficult.

3.2.4 Flooding of 1988

On November 21, 1988, a storm with high easterly winds caused a storm surge on the Miramichi River which resulted in extremely high tide elevations. During the storm, the windspeed at Chatham was measured at 45 km/hr with gusts to 80 km/hr, and 41 cm of snow fell in a 24 hour period (AES 1988). The maximum tide elevation was measured at 1.2 m above the predicted elevation at the Reference Port of Escuminac in Miramichi Bay (MEDS 1988; CHS 1988).

Flooding occurred throughout the study area (Figure 3.3), from Loggieville to Nelson Junction, inundating the Loggieville Village Wharf, Chatham Town Wharf, and the Douglastown Boat Club Wharf (The Telegraph-Journal, November 22, 1988). Commercial and private waterfront property was also affected by the high water levels.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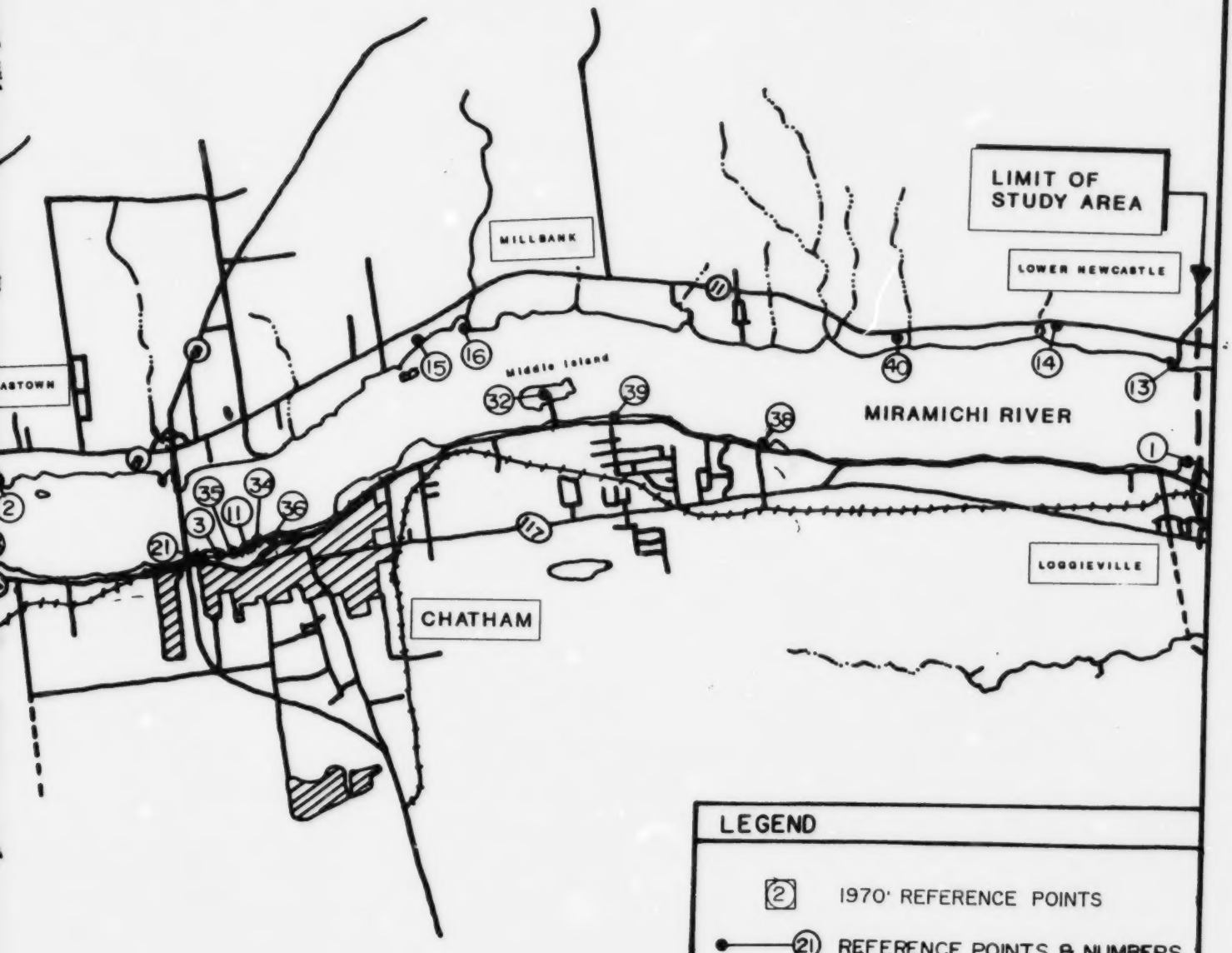

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2 1970' REFERENCE POINTS

21 REFERENCE POINTS & NUMBERS

RAILWAYS

ROADS

LIMIT OF STUDY AREA

1970 REFERENCE POINTS

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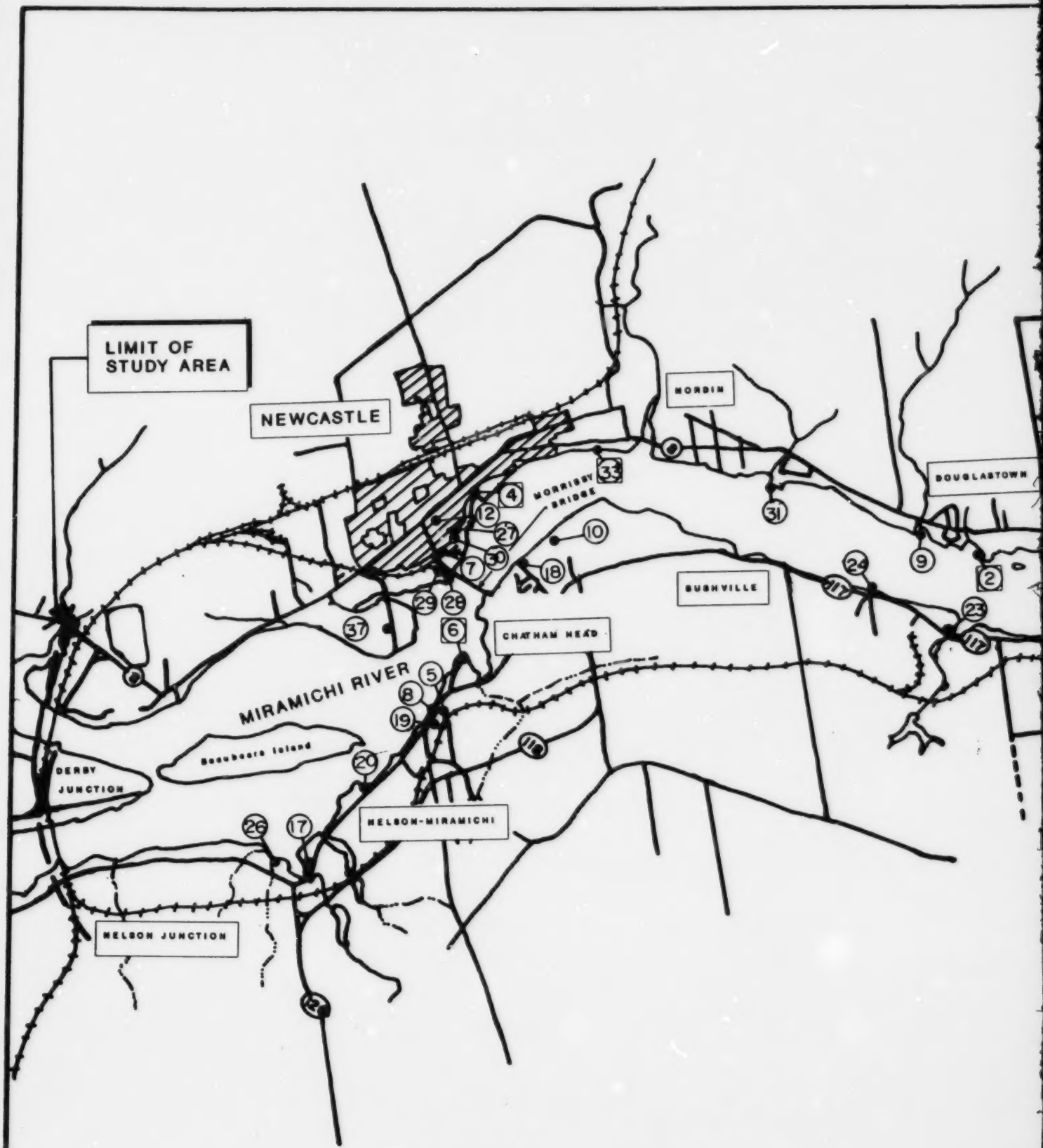
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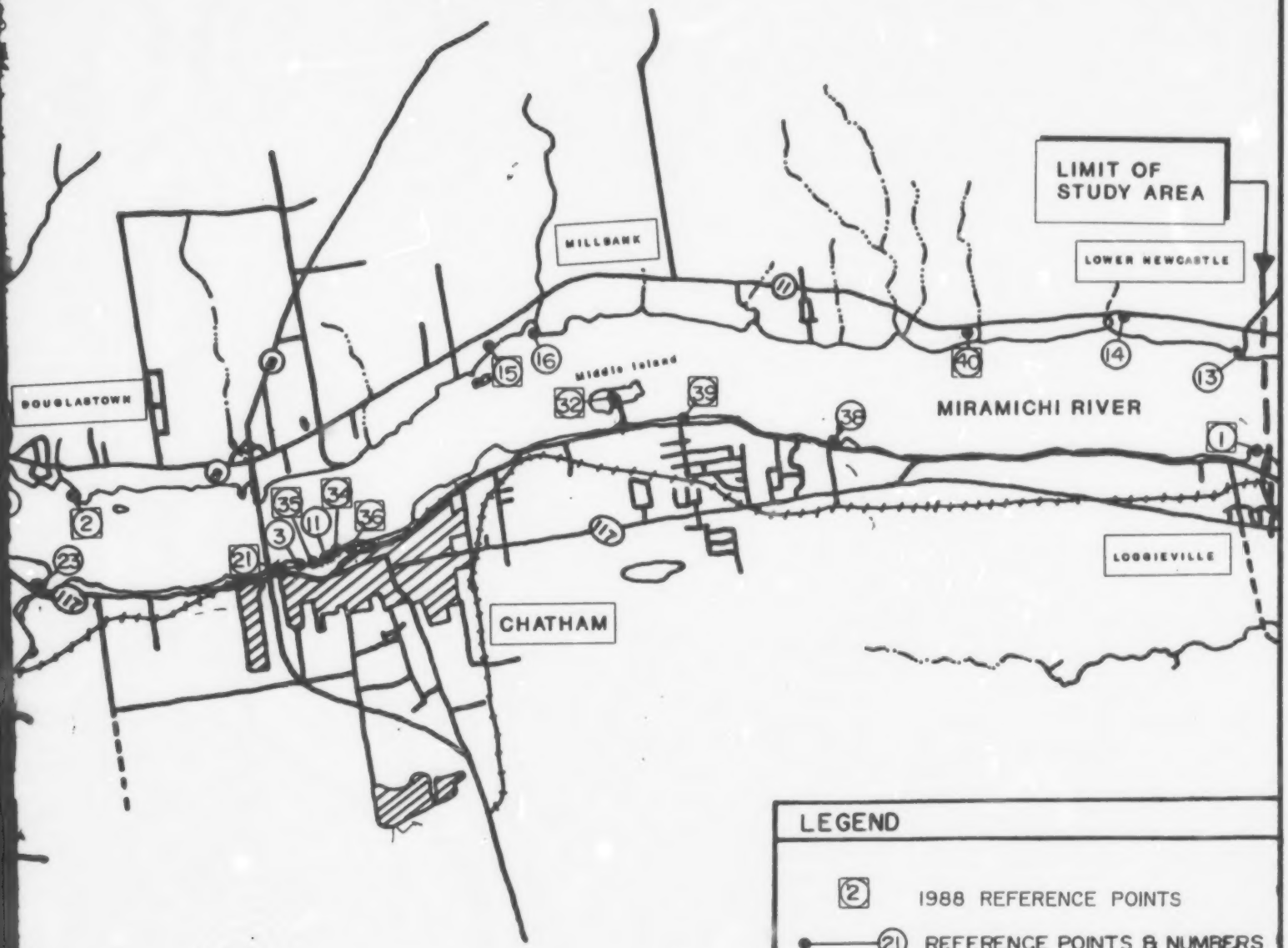

LEGEND

- 1988 REFERENCE POINTS
- REFERENCE POINTS & NUMBERS
- RAILWAYS
- ROADS
- LIMIT OF STUDY AREA

1988 REFERENCE POINTS

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SCALE: 1:50 000	DRAWN BY:
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This flood event was the one most easily recalled by people in the section of the study area downstream from Newcastle.

The Miramichi Basin Yacht Club in Douglastown lost moorings and other equipment from their wharves. At Burchill Plywood Ltd. in Nelson-Miramichi water came up to the floor of the boiler room and damaged an estimated $10,000 worth of veneer logs stacked on the wharf (K. Donaher, Plant Supervisor, pers. comm.).

The damage from the 1988 flood was not extensive since the majority of residences and businesses are located above the maximum elevation reached by this flood. A total of 16 reference points were found for this flood, covering the entire length of the study area (Figure 3.3).

3.2.5 Annual Flooding

Some portions of the study area are subject to minor flooding on an annual basis. There have been reports of flooding occurring during the spring freshet and ice run, which causes inundation of low-lying lands along the river (Tim Humes, pers. comm.). Heavy runoff also causes minor flooding within Chatham and Newcastle when the capacities of storm water drainage systems are exceeded. A sustained easterly wind tends to cause the predicted tide levels to be exceeded along the Miramichi River, giving rise to some flooding in the area (C. Reilly, pers. comm.). Flooding from a storm surge can occur at any time of the year.

During the study, 6 water level reference points related to annual flooding were found. All of the points found were ranked as vague and specific times of flooding were not given.

3.3 Field Survey

The details of the data collected by the surveyors during the field program are included in a separate report which provides the supplementary information for this study (Geoplan 1990). This report includes the field notes taken during the survey and the

descriptions of the benchmark locations. Table 3.2 presents the elevations and locations of the reference points found during the study which were used to determine the water levels for the flood events identified. Horizontal and vertical locations were determined for all points during the survey. A schematic of the survey route and closures obtained is shown in Figure 3.4.

3.3.1 Horizontal Control

The horizontal position of the reference points was accomplished by establishing New Brunswick stereographic grid coordinates for points identified. The coordinates were obtained by running closed traverses between New Brunswick monuments in the study area using a Wild T-1600 Total Station and Target System. The control hubs used were concrete nails in asphalt and 250 mm spikes in the ground, and are considered temporary in nature.

3.3.2 Vertical Control

None of the New Brunswick monuments in the area, with the exception of Monument #2011, was considered adequate for vertical control for geodetic datum. Consequently all elevations were established using a combination of spirit levelling and trigonometric levelling based on bench marks established by the Geodetic Survey of Canada. New Brunswick Control Monument #2011 is also a geodetic bench mark.

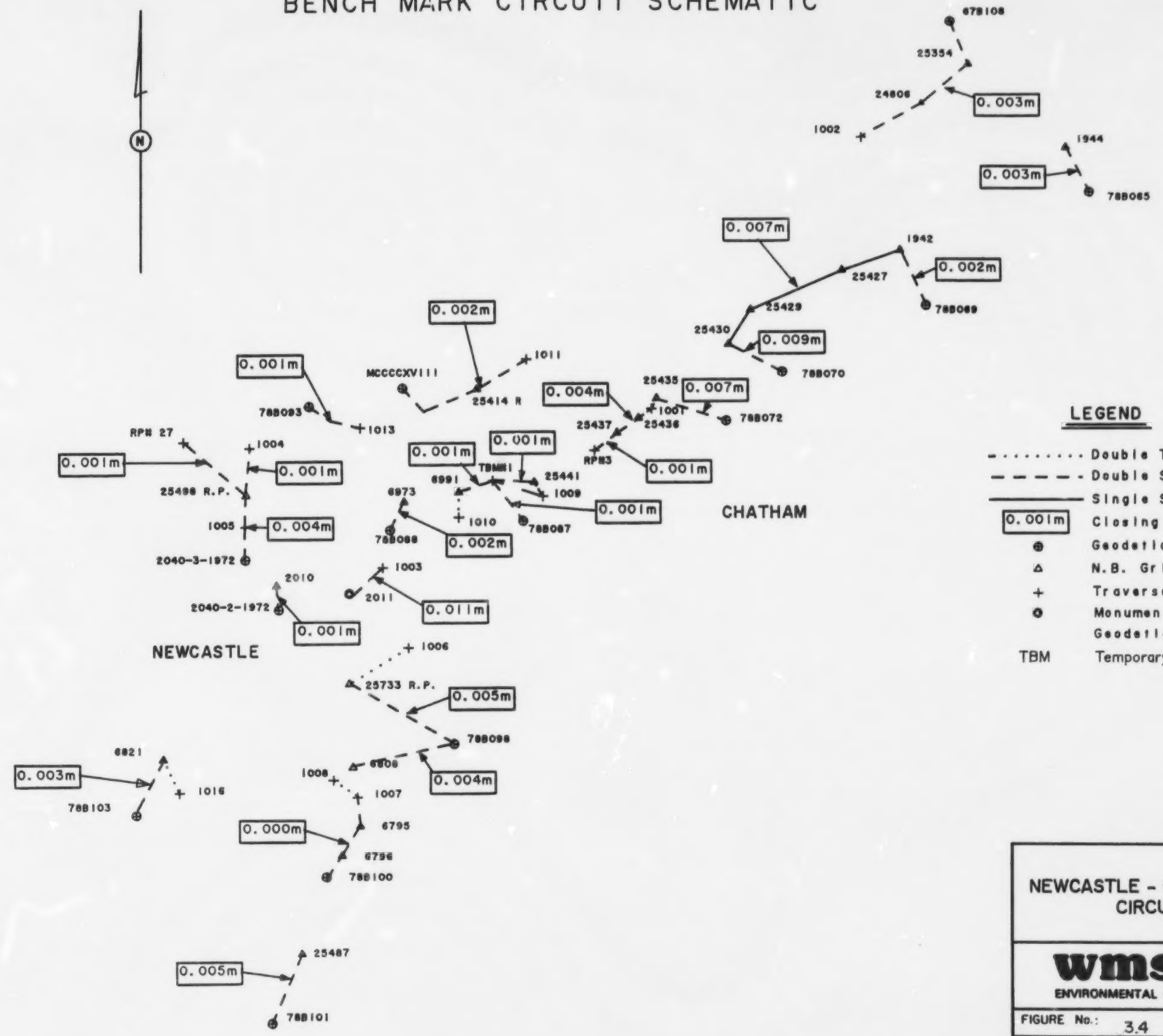
Spirit Level elevations were established on selected control stations with closed spirit level loops. The closing errors on these level loops were all less than 10 mm. The elevations for the reference points were established with the T-1600 Total Station and Target Systems using trigonometric levelling from the selected control stations.

TABLE 3.2: ELEVATION AND LOCATION OF REFERENCE POINTS

Point No.	Northing	Easting	Elevation
1	864427.6719	384684.3958	2.777
2	858719.6977	375976.0821	1.804
3	859328.4672	378134.2250	3.290
4	856765.7106	371242.0026	2.807
5	854325.8253	371951.6496	3.561
6	854913.4545	371959.2451	1.977
7	855916.8026	371121.3799	3.834
8	854371.1650	371919.2853	2.704
9*			
10	856425.4667	372083.0613	1.433
11A	859503.8856	378303.4072	3.135
11B	859447.3261	378261.2602	3.193
11C	859405.3446	378222.0616	3.070
12	856177.9198	371099.3338	3.757
13	864970.2105	384060.4783	1.500
14	864223.1975	382448.9942	2.296
15	861668.4207	378343.4013	2.888
16	862047.9655	378803.5016	2.226
17	852223.3777	371744.8289	4.188
18A	855978.3316	371946.8128	3.423
18B	855949.8997	371989.0506	4.139
19	854224.3790	371959.7778	3.294
20	853135.9360	371646.0448	3.026
21	859067.7427	377805.9746	2.592
22	852484.5106	369157.6343	2.953
23	857741.0979	376140.2132	1.240
24	857766.8594	375294.9035	1.569
25	850921.7437	369714.0744	4.203
26	852115.6658	371370.7807	2.905
27	856198.4893	371109.4005	3.976
28	855647.2013	371334.0412	2.693
29	855737.6516	371199.8575	3.500
30	856175.7385	371171.4818	2.762
31	858176.8303	373833.1850	1.484
32	861751.6991	379657.8309	2.006
33	857465.6567	371882.9378	3.383
34A	859464.6778	378196.0105	2.350
34B	859455.2673	378204.1872	2.294
34C	859446.0527	378211.8686	2.326
35	859397.8763	378126.7261	2.151
36	859732.6007	378369.9003	1.851
37	854957.4961	371016.1835	2.386
38	862516.1114	381556.1014	2.315
39	862028.2458	380290.2058	2.364
40	864005.4650	382140.8851	2.441

* Point not surveyed.

BENCH MARK CIRCUIT SCHEMATIC



SOURCE : GEOPLAN 1989

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- Double Trig Line
- Double Spirit Line
- Single Spirit Line
- 0.001m — Closing Error
- ⊕ — Geodetic Bench Mark
- △ — N.B. Grid Monument
- \+ — Traverse Hub
- ⊙ — Monument with Geodetic Elevation
- TBM — Temporary Benchmark Reference Point

NEWCASTLE - CHATHAM BENCH MARK CIRCUIT SCHEMATIC

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FIGURE No.: 3.4	JOB No.: 3029
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4.0 HYDROTECHNICAL CONSIDERATIONS

4.1 Introduction

This section of the report discusses the factors which may have an effect in causing or increasing the severity of flooding along the Miramichi River in the study area. The investigation of past flooding in the area has shown that flooding is relatively frequent, although major flooding is infrequent. Flooding appears to be related to the following factors:

- high tide levels;
- high runoff; and
- ice jamming.

A combination of these factors can occur causing an increase in the severity of floods in the Newcastle-Chatham area. The majority of population centres within the study area are located on the steep river banks above the level of flooding. There are, however, a number of structures and residences which can be affected by flooding, particularly the extremely high levels which can result from an ice jam flood.

Flooding can also occur if the tide levels, in conjunction with a storm surge from a sustained easterly wind, produce excessive water levels on the Miramichi River. This combination of events led to flooding in September 1940 and November 1988 and caused extensive flooding in the study area.

Within the Towns of Newcastle and Chatham local runoff during the spring snow melt period has occasionally caused localized flooding. At these times the capacity of storm drainage systems have been exceeded resulting in flooding of streets and structures. Local rivers and streams emptying into the Miramichi River also overtop their banks during these periods and cause flooding of local areas. This was a factor in the floods of 1953 and 1970 in the study area, which occurred in conjunction with a heavy ice run

and ice jamming on the Miramichi River.

4.2 Distribution of Flooding

The earliest recorded flooding in the study area occurred in June 1874; since that time there have been 41 recorded flood events (Table 2.1). The occurrence of flooding is fairly regular throughout the period of record. In some years, more than one flood has occurred. Examination of the flooding distribution shows that flooding can occur in any month of the year (Figure 4.1).

Figure 4.2 illustrates two concentrations of flood events, one in the spring (16 of 42 events), and one in the fall (10 of 42 events). The spring events are linked to high runoff due to heavy rains and snowmelt. The events occurring in the fall are due to the occurrence of a storm surge.

A seasonal breakdown has been used in Figure 4.2; the seasons have been defined as follows:

- spring, (March 1 to May 31);
- summer, (June 1 to August 31);
- fall, (September 1 to November 30); and
- winter, (December 1 to February 28).

There have not been major physical changes within the study area which could have affected the frequency or distribution of flooding. The 42 recorded flood events have occurred over a period of 114 years. Within each half of the 114 year period, there have been 21 flood events. The seasonal distribution of flooding is the same during

Figure 4.1 Temporal Distribution of Flooding

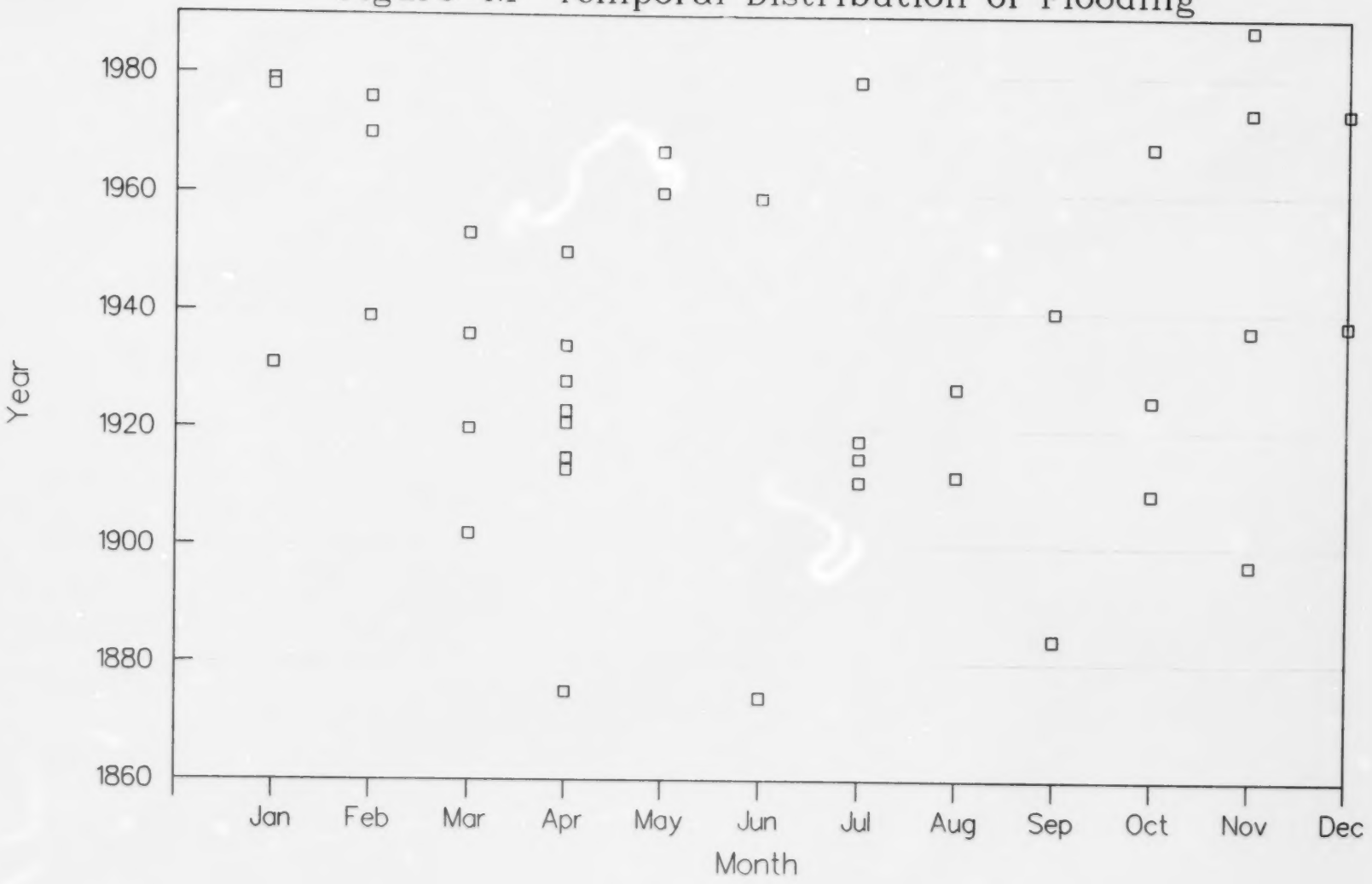
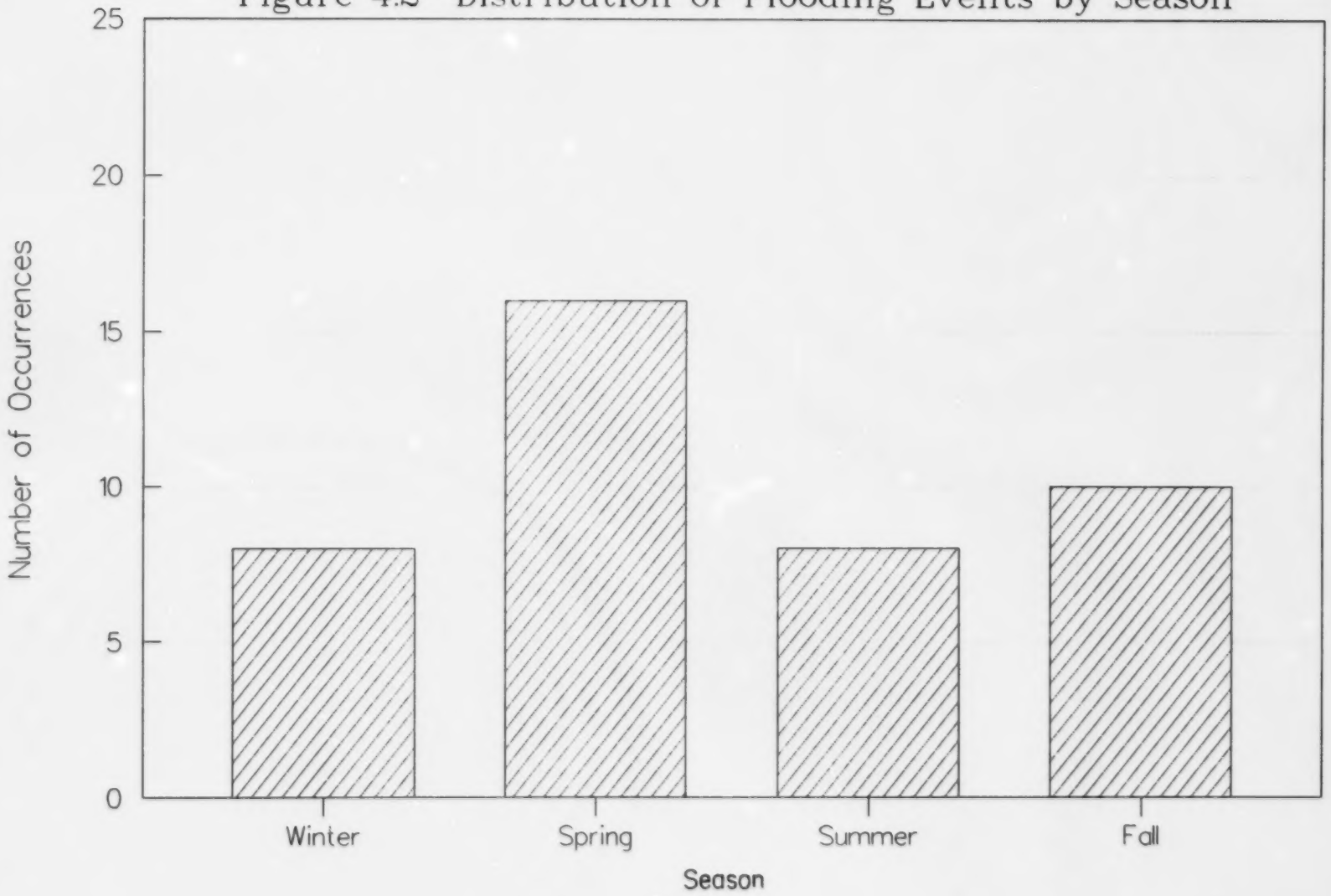


Figure 4.2 Distribution of Flooding Events by Season



both halves of the period. This confirms that there has not been any major changes within the study area which has affected the frequency and distribution of flooding.

4.3 Hydrologic Factors

4.3.1 Drainage Areas

The major watercourse in the study area is the Miramichi River. Small tributaries emptying into the Miramichi River in this area are not of significant size. Above Newcastle, west of Beaubears Island, the Miramichi River divides into the Southwest Miramichi River and the Northwest Miramichi River. The total drainage area of the Miramichi River at the Morrissy Bridge in Newcastle is estimated to be 11,565 km^2.

4.3.2 Flow Estimates

The flow on the Miramichi River at the Morrissy Bridge in Newcastle has been calculated for the 1 in 20 and the 1 in 100 year floods using regional flood frequency analysis (DMAE and IWD 1987). The results of this analysis have been compared to a single station frequency analysis undertaken for the Southwest Miramichi River at Blackville (Sta. 01BO001), which is the largest river in the region with a gauge; it has a drainage area of 5050 km^2.

The single station frequency analysis was conducted using the program CFA88 (IWD 1988) and reported in DMAE and IWD (1987). This showed peak flows for the 1 in 20 and 1 in 100 year events of 1560 m^3/s and 2050 m^3/s, respectively for the Southwest Miramichi River at Blackville. These flows were prorated to Newcastle at the Morrissy Bridge using the ratio of drainage areas. The estimated peak flows from this analysis were 3284 m^3/s and 4695 m^3/s for the 1 in 20 year and 1 in 100 year events, respectively.

In classifying the hydrographic regions for the purposes of regional analysis, the Miramichi River falls into the Central Hydrologic Region of the Province, as defined by DMAE and IWD (1987). Flows were therefore calculated using the equations for the

Central Region and compared to calculations using the Provincial regression equation. The results of the analyses are summarized in Table 4.1.

For all methods of calculating peak flows, the instantaneous peak flow has been used. The ratio of daily flow to peak flow was calculated using regional equations for the Central Hydrologic Region. This showed that for a basin with a drainage area of 11,565 km^2, the instantaneous peak flow and daily flow can be assumed to be equal (DMAE and IWD, 1987).

The equation for the Central Region gives the highest flows for the study area. The drainage area at the Morrissy Bridge is larger than the assumed range of applicability for the regional flood frequency analysis. It can, however, be used to provide an indication of the maximum flows. The following flows have therefore been estimated for the study area, and are the highest estimates from the Central Region equation:

- 1 in 20 year: 4220 m^3/s; and
- 1 in 100 year: 5614 m^3/s.

4.4 Hydraulic Factors

The record of flooding on the Miramichi River does not show evidence of floods associated with high flows during open water conditions. The high flows in the spring period may cause flooding during heavy ice runs or when ice jamming occurs, but generally does not produce extreme water levels unless associated with extreme tidal elevation due to a storm surge. Numerical modelling of the river profile under high open wales flows has shown that the effect of the flow on the water level at Newcastle would be to cause a rise of approximately 0.2 m above the maximum elevation of a large tide (Willis 1977). This effect was confirmed as part of this study using a HEC-2 computer model of the River at the Morrissy Bridge. The modelling indicated that the 1 in 100 year open water flow would cause an increase in water level less than 0.2 m above the tidewater level.

Table 4.1 Calculated Flood Flows for the Miramichi River at Morrissy Bridge

Equation	1 in 20 yr Peak (m^3/s)	1 in 100 yr Peak (m^3/s)
Central Region Equation[1]	4220	5614
Provincial Equation[2]	3254	3963
Proration from SW Miramichi[3]	3284	4695

Sources:

[1,2] - From Regional Flood Frequency (DMAE and IWD 1987)

[3] - Single Station Frequency Analysis (IWD 1988)

The observed effects from high open water spring runoff on the Miramichi River has been limited to reports of debris and logs from floods in the upper reaches of the Southwest and Northwest Miramichi Rivers. The debris is often washed ashore at Newcastle, or causes interference with navigation along the River.

The capacity of local storm water drainage systems can be exceeded during periods of heavy runoff. This has caused flooding in both Newcastle and Chatham in the past. It is estimated that 9 of the 42 floods on record were associated with local drainage problems. During the spring period, a heavy ice run on the Miramichi River may also interfere with drainage from local areas, causing additional flooding in areas away from the direct influence of the River.

Ice jamming has been responsible for some of the worst flooding in the study area. The flood at Newcastle in 1970 was caused by a major ice jam which formed just below the Morrissy Bridge. It is estimated that 9 of the 42 floods on record were associated with ice or ice jamming, although the descriptions of the flooding do not always provide a clear indication of the location of jams or resulting water levels. Some of the jamming has occurred at or near the Morrissy Bridge, although there is no direct evidence that it is responsible for the ice jams. It is possible that ice jams occur there as a result of a natural constriction of the Miramichi River. The ice runs on the Southwest and Northwest Miramichi Rivers usually jam in a number of places upstream before reaching Newcastle. Any obstruction to the flow, such as bridge piers in the River, could therefore cause the ice run to stop and jam.

4.5 Tidal Factors

The study area is in the estuary of the Miramichi River and is subject to regular tidal fluctuation. The reference port for the tide levels on the Miramichi River is Escuminac, located at the mouth of Miramichi Bay. The normal and large tidal ranges for Chatham and Newcastle are shown on Table 4.2. Under normal circumstances, these tidal variations do not cause flooding in the study area. However, weather conditions, such as wind and atmospheric pressure changes acting on the sea surface, can

Table 4.2 Miramichi Tides

	Tide Ranges		Time Differences	
	Large (m)	Average (m)	HHW (min)	LLW (min)
Escuminac	1.52	1.04	--	--
Chatham	1.71	1.16	90	90
Newcastle	1.74	1.19	104	110

Note:

HHW - Higher high water
LLW - Lower low water

Time differences refer to the number of minutes delay before HHW and LLW reach the station after having reached Escuminac.

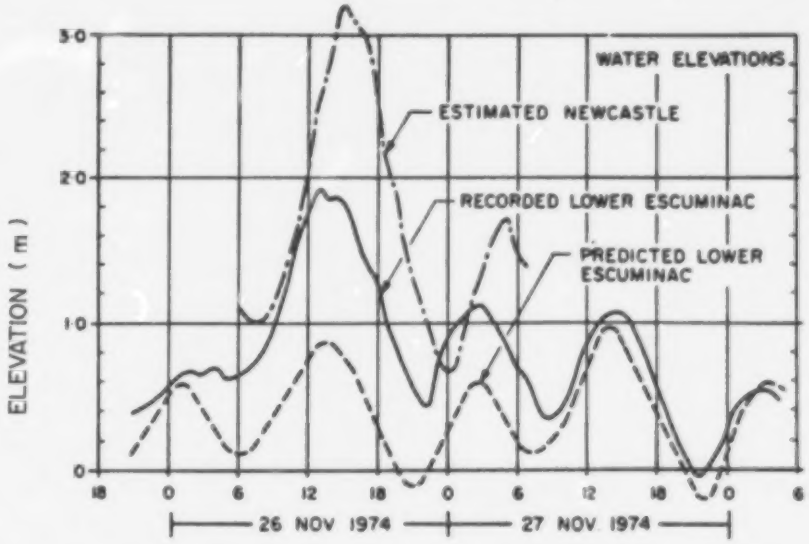
Source: Gulf of St. Lawrence Tide Tables (CHS 1988).

influence the tides and cause an increase in the tidal range. This variation is typically 0.1 to 0.3 m, only occasionally reaching 0.5 m (Public Works Canada 1978).

Extreme weather conditions can cause a storm surge which can result in maximum water levels which greatly exceed the predicted high tidal elevation. The records of flooding show that at least 14 of the 42 floods in the study area were related to storm surge effects. The Miramichi Channel Study (Public Works Canada 1978) investigated the effects of a storm surge on the Miramichi River in November, 1974. During this storm, the water level at Escuminac reached 1 m above the predicted level and the level at Newcastle exceeded the predicted level by over 2 m (Figure 4.3). There were no reports of flooding in the area during this event.

Tidal records during the 1988 flood in the study area were reviewed and showed that the tide levels at Escuminac exceeded the predicted levels by 1.2 m (Figure 4.4). Estimates of the resulting water levels at Newcastle and Chatham have not been made, since this requires the application of a sophisticated computer model (D. Spear, pers. comm.)

A computer model has been developed for the prediction of tidal water levels along the Miramichi River (S. deMargerie, pers. comm.). This model has been used to calculate the water level at Chatham or Newcastle based on recorded levels at Escuminac. It can also be used in a predictive mode to determine the anticipated water levels at these points due to atmospheric conditions. The model could be used to give a warning of expected high water levels which could cause flooding in the study area.



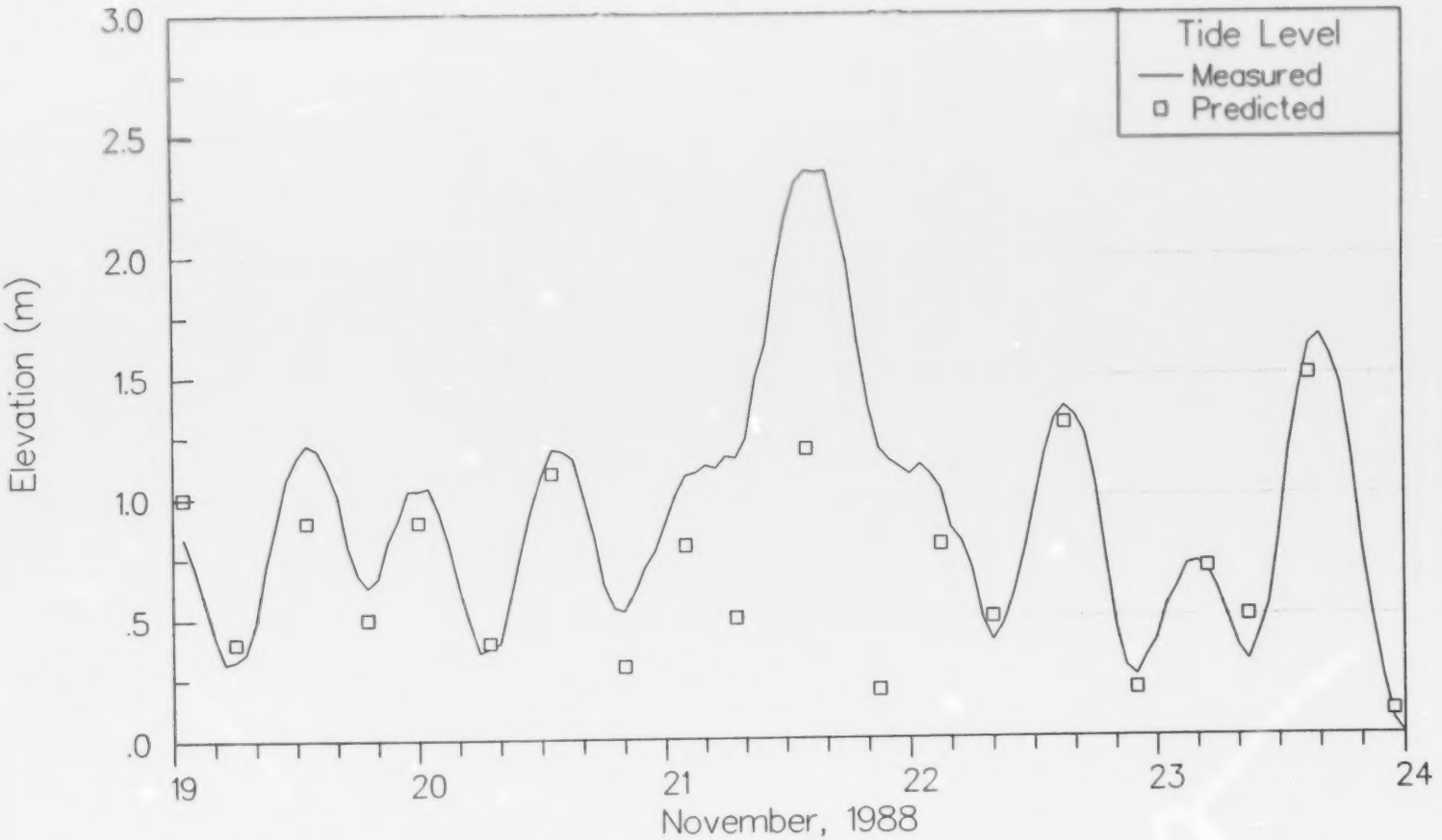
SOURCE : WILLIS 1977

PREDICTED AND RECORDED TIDE HEIGHTS, 1974

wms associates ltd.
ENVIRONMENTAL CONSULTANTS AND SCIENTISTS

FIGURE No.: 4.3	JOB No.: 3029
SCALE: NTS	DATE: 90 01 24

Figure 4.4 Tidal Variation at Escuminac N.B.



Note: Elevations are to chart datum

5.0 ENVELOPE OF MAXIMUM FLOODING

The envelope of maximum flooding was derived by an evaluation of the water levels at the reference points collected during this study. Due to the variation in the water levels found throughout the study area it was necessary to evaluate the points and water levels which were found to arrive at a best estimate of the maximum level of flooding in the study area. The points were plotted on a profile of the Miramichi River and on the best available mapping of the study area to assist in the evaluation.

The profiles and plotting of the water levels for the area are discussed in the following section. Mapping used for this study is included with the supplemental data (WMS 1990).

During the research and interview phase of the study, information on 5 flood events covering a period from 1940 to 1988 was found to be sufficiently detailed to allow identification of points in the field. Information was also found on flooding which occurs in some areas on an annual basis and additional information was found on points of flooding where the flood date was not known. The research phase of the study identified 50 reference points, at some of these points information on more than one flood event was identified. The field survey measured the horizontal location of 40 of the reference points. At some of the reference points, more than one water level was measured. In some cases the additional water levels were due to more than one flood event being identified at the reference point, e.g., reference points 4, 6 and 20 (Table 5.1). At other reference points, more than one elevation was determined for a single flood event. This occurred at reference points 11, 18 and 34 (Table 5.1) due to the researcher identifying different elevations in the vicinity of one reference point which represented the same event.

TABLE 5.1 ELEVATIONS AND RANKING FOR WATER LEVEL POINTS

Point No.	Distance	1940	1953	1970	1976	1988	Annual	Unknown	Max. Envelope of Flooding
1	22000					2.78 A			2.78
2	11360					1.80 R			3.50
3	13560				3.29 R				3.39
4	5990	2.81 V		3.20 A		2.06 A			4.14
5	4120			3.56 A					4.16
6	4500			3.12 G		1.98 R			4.16
7	5920	Y		3.83 A					4.14
8	4200			3.32 G					4.16
9	10660						Y		3.53
10	6600							1.43 A	4.14
11 A	13720							3.14 A	3.38
11 B	13720							3.19 A	3.38
11 C	13720							3.07 A	3.38
12	5900	3.76 V							4.14
13	21960							1.50 V	2.78
14	20440						2.30 V		2.90
15	15380					2.89 R			3.27
16	15820							2.23 V	3.24
17	2440			4.19 R					4.18
18 A	6830			3.42 R					4.13
18 B	6830			4.14 V					4.13
19	4060			3.49 A					4.17
20	3100		3.03 A	3.48 A					4.18
21	13040					2.59 A			3.41
22	760			2.95 R					4.20
23	11200							1.24 V	3.50
24	10740						1.57 V		3.53
25	80			4.07 A		4.05 A			4.21
26	2040						2.91 V		4.19
27	5940			3.98 A					4.14
28	5450			2.99 R					4.15
29	5600			3.50 A					4.15
30	5920			3.07 A					4.14
31	9180						1.48 V		3.60
32	16320					2.01 A			3.20
33	7200					3.38 R			3.70
34 A	13660					2.35 A			3.38
34 B	13660					2.29 A			3.38
34 C	13660					2.33 A			3.38
35	13470					2.15 A			3.39
36	13760					1.85 V			3.38
37	4620			2.99 V			Y		4.16
38	18320							2.32 R	3.05
39	16880					2.36 A			3.16
40	19520					2.44 V			2.97

Note: Water level elevations in metres
Distance is chainage along River downstream from railway bridge at Upper Nelson in metres

Label	Description	Range
G	Good	25 mm
R	Reasonable	75 mm
A	Approximate	150 mm
V	Vague	300 mm
Y	No Elevation	

Table 5.1 summarizes the elevations established for each of the reference points and provides a measure of the reliability of each point. Table 5.2 summarizes the ranking for the flood events for which information was found during this study. It may be seen that the largest amount of information was found for the 1970 flood event, followed by the 1988. As discussed in Section 4, the 1970 flood event was due to an ice jam at Newcastle and resulted in the highest water level on record for the portion of the study area in Newcastle and upstream.

The majority of the water levels found in the study area for the 1970 flood were ranked as either Reasonable or Approximate; only 2 water levels were ranked as Good (Table 5.2). This means that the levels determined to represent the envelope of maximum flooding in this study may vary by ± 150 mm. The level selected for the tidal flooding downstream of Newcastle is based on points which were ranked as Vague and therefore the envelope of maximum flooding may vary by ± 300 mm in this area.

5.1 Flow Profiles

The Miramichi River in the Newcastle-Chatham area is confined by river banks which are generally quite steep. The population in the area is largely located at elevations which would not be affected by flooding. In reviewing the water level elevations, it was found there was a wide variation of the elevations, making it difficult to determine the maximum envelope of flooding. This variation could be due to a number of factors:

- water levels recorded for the points may not be at the peak of the flood;
- features of the terrain in the study area could cause a variation in the water levels; water could backup behind some features, such as roads or railway embankments; or
- individual recall of water levels may not always be accurate for determining maximum levels.

TABLE 5.2: SUMMARY OF POINT RANKING

	G	R	A	V	Y	Total
1940	0	0	0	4	1	5
1953	0	0	1	0	0	1
1970	2	4	9	1	0	16
1976	0	1	0	0	0	1
1988	0	4	8	2	0	14
Annual	0	0	0	4	2	6
Unknown	0	1	2	3	8	14
Ttl Points	2	10	20	14	11	57

Label	Description
G	Good
R	Reasonable
A	Approximate
V	Vague
Y	No Elevation

In order to determine the elevations to be used in plotting maximum historic flood levels, it was necessary to carefully review all points found. Within the study area there are two main groups of points which must be investigated to determine the maximum envelope of flooding. These are the points related to the ice jam flood of 1970 which affected the Town of Newcastle and the points related to storm surge flooding in 1940 and 1988 which affected the entire study area. Each of these were investigated separately, although the maximum envelope of flooding must be taken as the maximum level reached in any area. The maximum envelope of flooding considers all points found in the course of the study.

5.1.1 Ice Jam Flood Profile

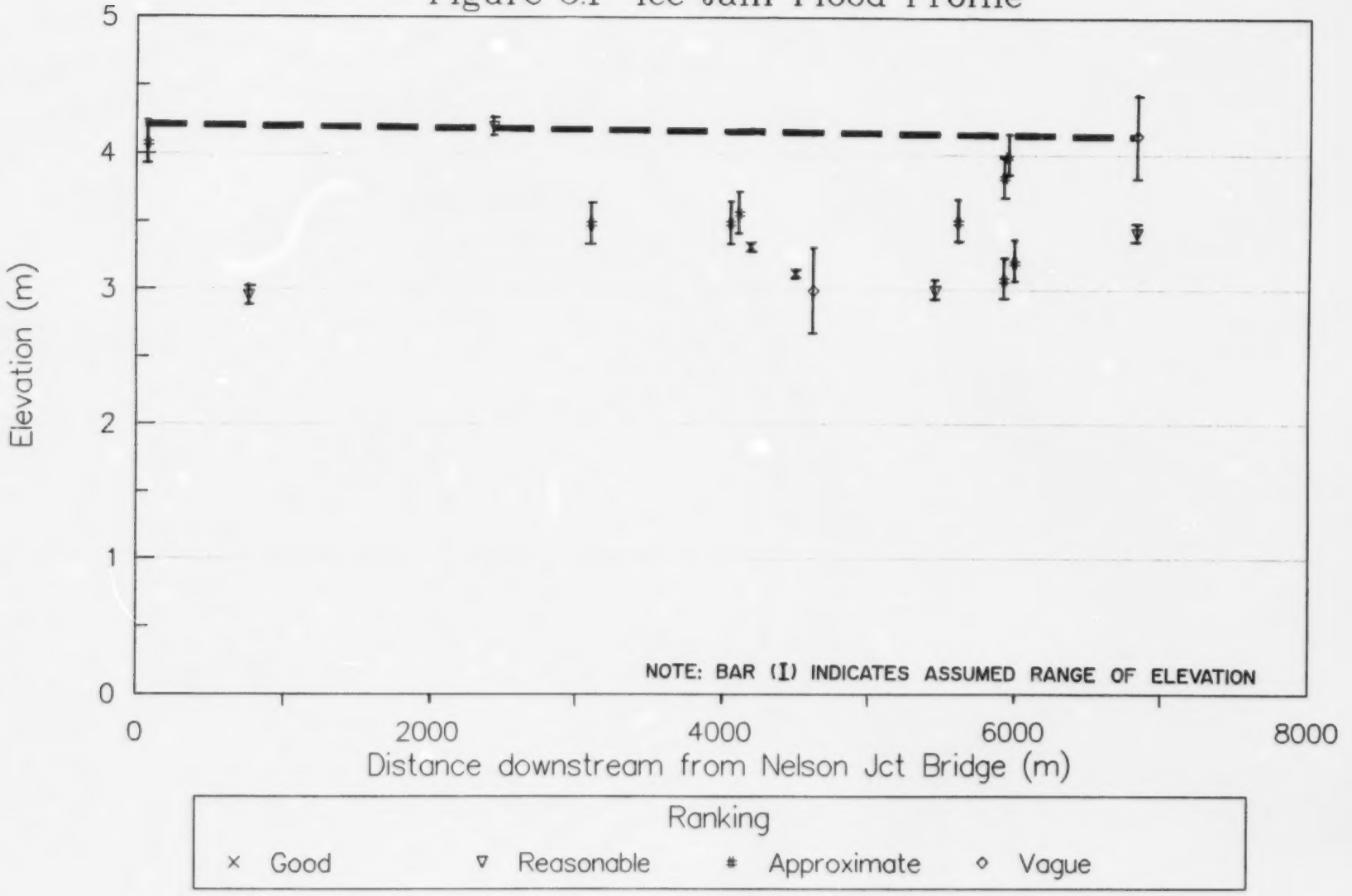
There were a total of 17 reference points found related to the 1970 ice jam flood in Newcastle. These were plotted on a profile of the Miramichi River to give an indication of the variation of the water levels given by these points (Figure 5.1).

There was considerable variation in the water levels found relating to the 1970 ice jam event. This would be due to the transient nature of the water levels behind an ice jam, the time of observation of the water levels and observation error. The highest water levels found during the study were used to establish the maximum envelope of flooding for the ice jam event. These were points 17 and 18, at which water levels of 4.14 m and 4.19 m, respectively, were found. These points indicate a slight slope to the water surface profile and were used to estimate the elevations for the maximum envelope of flooding between the bridge at Nelson Junction and the Town of Newcastle (Table 5.1).

5.1.2 Tidal Flood Profile

There were two historic floods in the study area which relate to tidal flooding on the Miramichi River. These occurred in 1940 and 1988. During the study, 16 water level reference points were found relating to the 1988 flood and 4 points were found which provide elevations for the 1940 flood. These points were plotted on a profile of the

Figure 5.1 Ice Jam Flood Profile



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Miramichi River in the study area and used to determine the maximum envelope of flooding.

The review of the points related to the 1988 flood showed a variation in the water levels which was greater than the range assumed for the ranking which had been assigned to the points. Some of this variation was due to the time of the flood peak, which was reported to have occurred at night when observation is difficult. In addition, the tidal flooding did not affect many residences or businesses so there was no major damage which would have highlighted the maximum level of the flood.

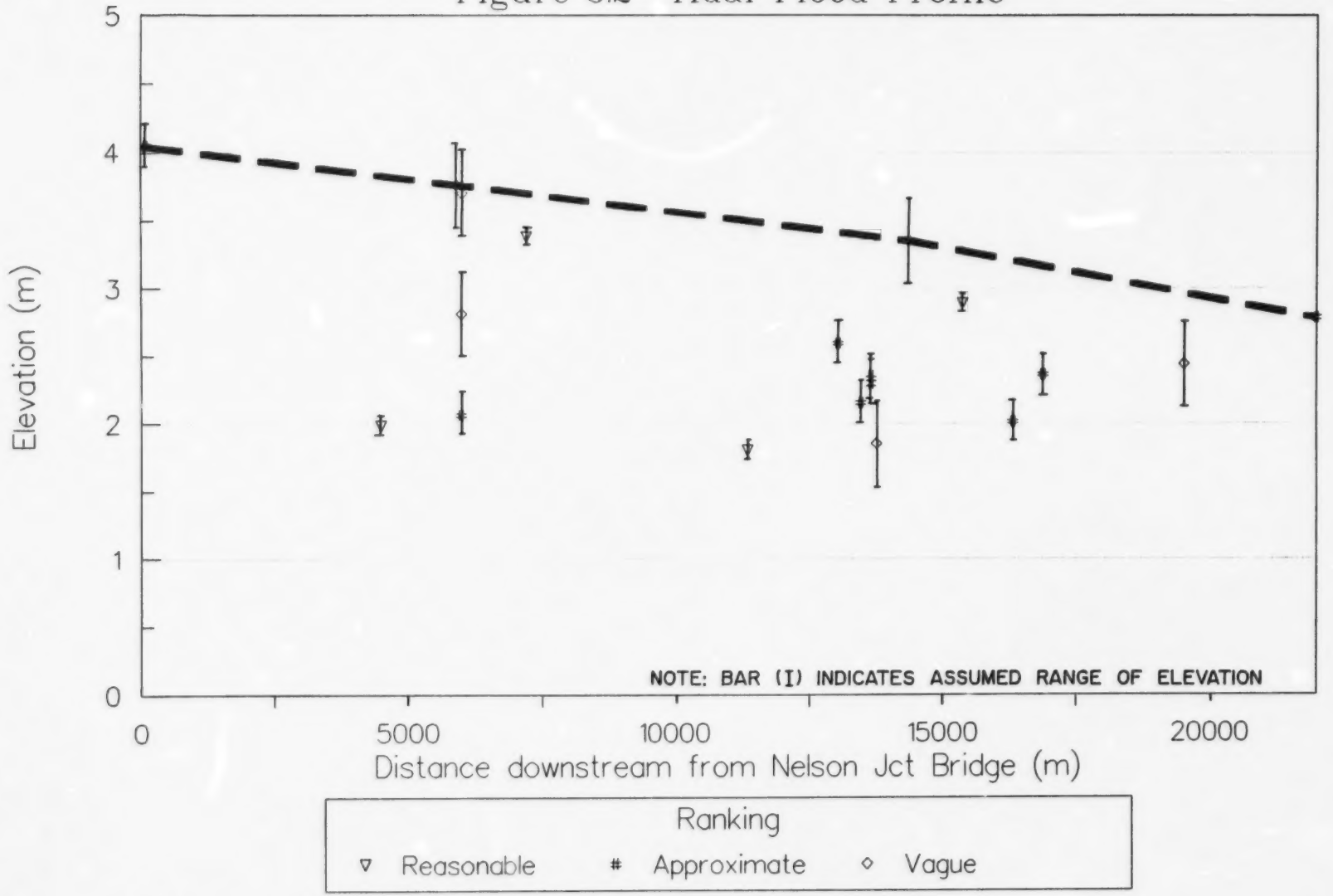
The 1940 flood occurred over 30 years ago and location of reference points was difficult. Many structures in the study area which were affected have been changed or removed. It was also difficult finding residents of the area who have first hand knowledge of the flood. The major source of information on this flood was therefore newspaper accounts of the flood.

The envelope of maximum flooding for the study area was selected based on the reference points with the maximum water level elevations. These were reference points 12 and 50, related to the 1940 flood event, and point 1 related to the 1988 flood event. These points indicate a slope on the water surface profile in the study area and were used to determine the elevation of the maximum envelope of flooding. All other points related to the tidal flooding of 1940 and 1988 fall below the envelope established by these points, as indicated on Figure 5.2.

5.2 Historic Flood Limits

The maximum historic flood limits were plotted on the best available mapping of the area. These were used to assess the extent of flooding in the study area and to determine the areas which would be affected by the maximum historic flood levels. The maximum envelope of flooding for the Town of Newcastle and upstream to the limit of the study area at Upper Nelson was established based on the water level reached by the 1970 ice jam flood. The maximum envelope of flooding for the portion of the study area downstream of Newcastle was determined from the water levels

Figure 5.2 Tidal Flood Profile



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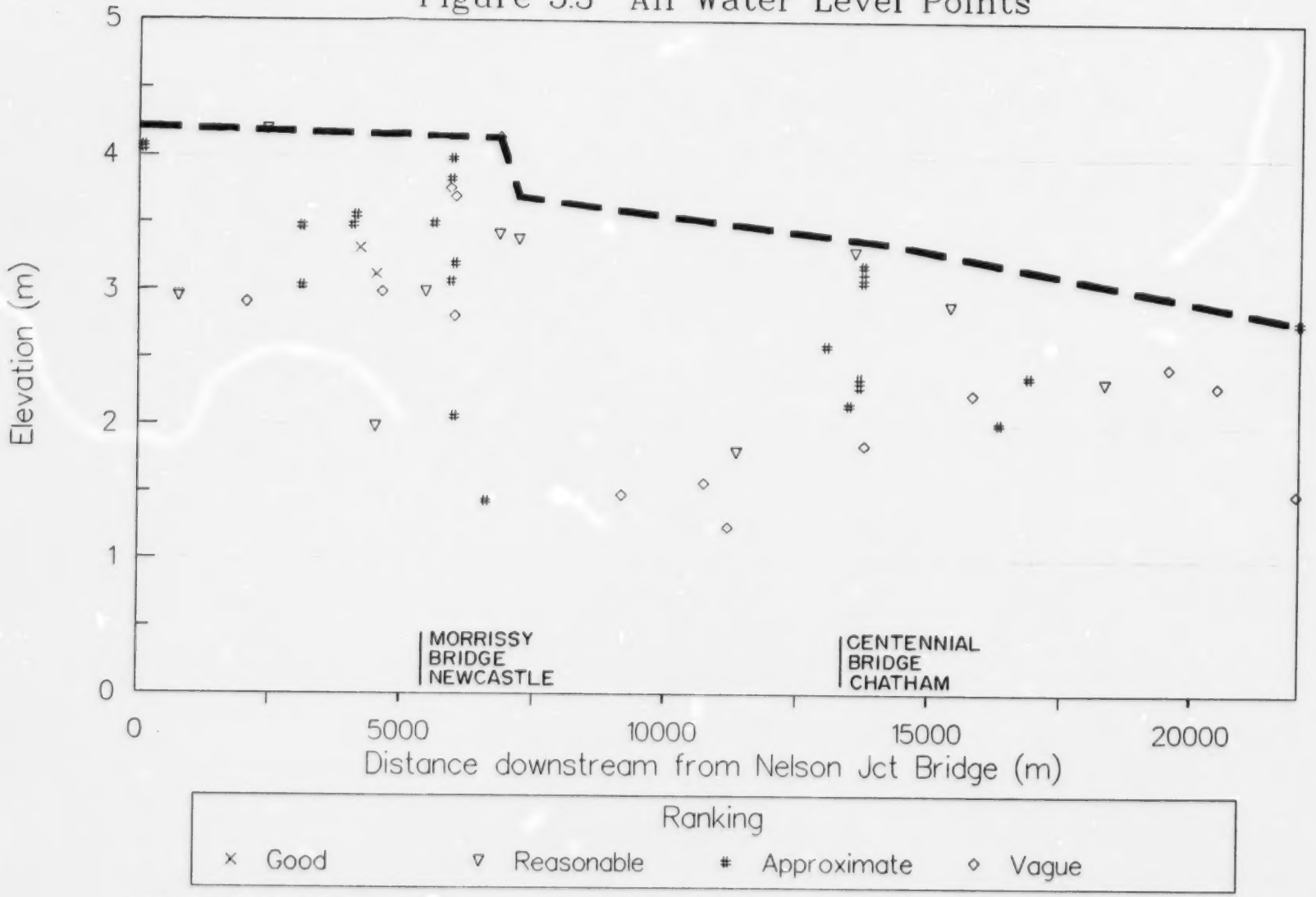
which occurred during the 1940 and 1988 flood event, which were caused by extreme tidal elevations due to a storm surge. Figure 5.3 shows the water level at all reference points and indicates the envelope of maximum flooding for the entire study area. Table 5.1 indicates the elevation of the maximum envelope of flooding at each reference point in the study area.

Figure 5.3 All Water Level Points



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6.0 CONCLUSIONS AND RECOMMENDATIONS

This study determined that the floods of 1940, 1970 and 1988 produced the highest water levels on record in the study area. The maximum envelope of flooding was determined based on the highest water levels from these events. Elevations of the maximum envelope of flooding were determined along the length of the study area and can be used to establish the flood risk areas.

The flood of 1970 was a result of an ice jam located downstream of the Morrissy Bridge in Newcastle which caused extensive flooding of Newcastle and the area upstream.

The 1940 and 1988 events were the result of extremely high tides caused by storm surges. These events produced the maximum water levels for the portion of the study area downstream of Newcastle.

It was determined that some localized flooding occurs within Newcastle and Chatham due to the capacity of the storm water drainage system being exceeded. This flooding occurs during times of high runoff from the local drainage areas within these Towns. This study did not delineate the extent of inundation from this type of flooding, but it was determined that some flooding does occur outside the maximum envelope of flooding due to these localized effects.

The water levels found in this study were reported as elevations of flooding or heights against structures. The exact extent of inundation was not given at these points and was estimated from the topographic mapping of the area.

The 1 in 100 year flow on the Miramichi River at the Morrissy Bridge was estimated at 5600 m^3/s. It was determined that this flow would not cause a significant increase in the water level above the normal tidal range.

It is recommended that the maximum envelope of flooding determined in this study be used in the designation of flood risk areas within the study area.

It is also recommended that any developments within the study area which encroach upon the river or restrict river flow be carefully considered in relation to their effect on the ice regime and ice jams. New construction such as bridges and wharves should not restrict the movement of ice or present new lodgement points which could cause an ice run to stop and jam. Such changes could increase the severity of jamming and increase the maximum envelope of flooding within the study area.

Localized flooding within Newcastle and Chatham has occurred due to under capacity of storm water drainage systems. It is recommended that a review of the stormwater drainage capacity be undertaken to highlight changes to the system which could be carried out to alleviate this type of flooding.

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APPENDIX A

WMS 3029

DOCUMENTATION AND ASSESSMENT OF FLOODING
MIRAMICHI RIVER
NEWCASTLE-CHATHAM AREA

LOCAL RESIDENTS AND OFFICALS INTERVIEW GUIDE

Name: _____

Address: _____

_____

Organization: _____

Position: _____

Telephone: _____

Interview guide # _____

1. What years do you remember flooding in the Sackville Area?

_____ _____ _____

Fill in **Flood Event Information Form** for each year.

2. Do you have any records or recollections that might provide information on past floods, such as:
   . the height of water
   . location of ice jams
   . photographs and films of flooded areas
   . locations of high water marks
   . damages

   No _____ Go to Q.3

   Yes _____ Fill in **Flood Event Information Form** for each event and/or piece of information.

3. Can you think of any other individuals or organizations that may have that type of information or evidence?

No_____ Yes_____ Could you please provide names, locations and telephone numbers so that we may contact these individuals?

(a) Name: _____ Tel: _____

Location and Comments: _____

_____

_____

(b) Name: _____ Tel: _____

Location and Comments: _____

_____

_____

(c) Name: _____ Tel: _____

Location and Comments: _____

_____

_____

(d) Name: _____ Tel: _____

Location and Comments: _____

_____

_____

(e) Name: _____ Tel: _____

Location and Comments: _____

_____

_____

WMS 3029

DOCUMENTATION AND ASSESSMENT OF FLOODING

MIRAMICHI RIVER NEWCASTLE-CHATHAM AREA

FLOOD EVENT INFORMATION FORM

Interview guide # _____

A. Date event started: _____

Time: _____ Don't Know ( )

B. Date event peaked: _____

Time: _____ Don't Know ( )

C. Duration of flood: _____

D. Describe location and extent of flood waters. (Provide sketch or locate on map.)

_____

_____

_____

E. How high was the flood? (Describe and photograph, or give level if known):

_____

_____

_____

F. Do you know the type of flood?
Describe appropriate flood type.

(a) Ice Run ( )
Ice Jam ( )

Do you know where the ice run/jam was located? (Cross out one)

No ( ) Go to G.
Yes ( ) Please describe the location and height of run/jam (if known). (Provide sketch or locate on map.)

_____

_____

_____

(b) Open Water ( )

_____

_____

(c) Tidal ( )

_____

_____

(d) Don't know ( )

G. What damages did the flood cause to specific structures and what was the cost of damages?

None ( )
Don't know ( )

_____

_____

H. Are you aware of any remaining scars, physical marks or evidence of flooding (e.g. on buildings, trees, other structures) that show the level the water reached?

No ( ) Go to I.
Yes ( )

(i) Please describe the location and the type of mark as accurately as possible so that our surveyors may locate it. (Take photograph and provide sketch and/or location on map)

Description and location of Marks

_____

_____

_____

_____

_____

I. Do you have any photographs, films or videos that show this flood event (or the marks you mentioned)?

No ( )

Yes ( )_____Photograph ( ) Video ( )
Film ( ) Other ( )

Can we have access to a copy of these?

Print provided ( )
Negatives provided ( )
Lent for duration of study ( )
Can ask for it when doing actual surveying? ( )

Photo taken of mark ( )
Photo taken of photo ( )

APPENDIX B

LIST OF PEOPLE INTERVIEWED
NEWCASTLE-CHATHAM AREA

Anna Allen
Steve Allen
William A. Allen
Mrs. Bateman
Ruby Blackmore
Brenda (Clerk Loggieville)
Haley Christiansen
John Copps
Oscar Corey
Bill Currie
Lew Dickson
Willis Dickison
Keith Donahern
Editor, Miramichi Leader Weekend
Jackie Fallon
Jack Flanagan
Ferris Ferris
Electa Foley
Marie Foley
Jean Stohtart Gilmore
Vernon Goodfellow
A.P. Tracy-Gould
Emily Hanscombe
Bill Hicks
Tim Humes
Bob Jardine
Mike Kenny
Agnes Kirk
Librarian (Newcastle)
Don MacDonald
Vince MacKenzie
Parker Manderson
Darlene Morrice
Doug Matheson, Manager Dewey Photography
Mr. & Mrs. Stephen McCarthy
John Norton
Eva O'Neil
Joe O'Neil
Jim O'Neil
Wiliam Ramsey
Melda Reynolds
Mrs. Alvin Scott
H.V. Sturgeon
Mrs. Harry Taylor
Pat and Winston Tracy
Jack Ullock
Florida Viennaux